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REPORT OF ROUND TABLES ON USE OF ELECTRIC SHOCK

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At the meeting of the New York Branch of the American Psychological Association, held at Yale University in April, 1933, a Round Table met to discuss the use of electric shock in psychological experimentation. This meeting was attended by about forty people brought together to exchange views regarding some of the difficulties involved in electrical stimulation. The interest aroused at this meeting and the importance of the problems discussed led to the organization of a second Round Table at the next annual meeting of the American Psychological Association at the University of Chicago. At that time it was voted to organize a Committee of the Round Table to study and to make recommendations on the problems which had been raised. The committee members were: H. Cason, C. W. Darrow, K. Dunlap, T. W. Forbes, T. A. Jackson, H. H. Jasper, T. N. Jenkins, C. Landis, R. Likert, I. Lorge, L. W. Max, K. F. Muenzinger, C. A. Ruckmick and G. R. Wendt (chairman). During the course of the following year this group prepared five brief papers on the major problems of electric shock. These were presented and discussed at a third Round Table at the annual meeting of the Association at Columbia University (September, 1934). At that time it was voted to continue the Committee of the Round Table in active form as an Executive Committee consisting of T. W. Forbes, K. F. Muenzinger and G. R. Wendt (chairman). The purposes of the committee have

been: (1) to stimulate interest in the problems of shock and to make known the defects of present techniques, (2) to stimulate, sponsor, and prosecute research on the problems of shock, (3) to coördinate the efforts of those working on the problems of shock, and (4) to collect facts and to make recommendations in connection with the use of shock.

This paper represents an attempt to summarize the proceedings of the three Round Tables in such a way as to present the problems raised and the few conclusions and recommendations which seemed to emerge. These problems were discussed under five sub-divisions: (1) those raised by the use of the electric grille in animal experiments (considered by T. A. Jackson for the Committee); (2) those of the physical and physiological factors of importance in the use of shock by psychologists (C. W. Darrow, T. W. Forbes, H. H. Jasper, C. Landis, R. Likert); (3) those of the psychological factors of importance in the use of shock (H. Cason and C. A. Ruckmick); (4) those of the standardization of procedures (K. Dunlap, T. N. Jenkins, and K. F. Muenzinger); and (5) precautions against lethal shock (I. Lorge and L. W. Max).[1]

The Major Problems in the Use of Shock

(1) *The Problem of the Grille.* The problem which has aroused the most active discussions at the Round Tables has concerned the use of the grille in animal experiments. For a number of years experimental work involving its use has enjoyed an undeserved freedom from criticism. The discussions at the Round Tables drove home the conclusion that present techniques fail to achieve control of the intensity of the shock. The object to be striven for is that each shock be approximately equal. The difficulty lies in the fact that as the animal moves across the grille *the area of contact with the electrodes varies.* Along with this variation in area of contact will go a variation in stimulus strength. The magnitude and direction of this variation will depend upon the nature of the circuit used.

It has been common procedure in electrical stimulation to attempt to control the intensity of shock by controlling the amount of current

[1] This paper was prepared from the materials in the hands of the committee chairman. These consisted of notes of the proceedings of the three Round Tables, correspondence with members of the Round Tables, and especially of the papers prepared by the committee members for the 1934 Round Table. The views presented in this report should therefore be attributed to no individual except in those cases where their origin is stated.

which can flow. One method of doing this is to use an external current source of high voltage which is then passed through a large resistance in series with the grille so that the current is reduced to the desired value. The object of this method has been to reduce the variations introduced by individual differences in the resistance of the animals, for in this circuit the resistance of the animal constitutes but a small fraction of the total resistance, and variations in the former will therefore cause only an insignificant change in the amount of current which passes.[2] But, while solving the problem of current variation with individual differences in resistance, the method has at the same time enormously exaggerated the effects of variations in area of contact. By putting a large series resistance in the circuit, the maximum amount of current which can flow is strictly limited. The *stimulation* effect of this current will then be a function of area of contact. As the area of contact varies, the amount of current passing through any one excitable point will be changed. Suppose, for instance, that the apparatus is adjusted to pass 1.0 milliampere of current. When the area of contact is small, all of this current will enter the tissue through a narrow channel. The *current density* in this channel will consequently be very high. As the area of contact is increased, the same 1.0 m.a. of current will flow, but it will be distributed in a wider channel. Within this channel the current density will be proportionately low. The physiological response in the two situations would be expected to be quite different. In the actual experimental situation, as the rat runs across the grille the area of contact may change from a minimum (where the shock will be at a maximum) to a maximum (where the shock will be at a minimum). Some unfortunate consequences of this situation are illustrated by the fact that an animal will sometimes sit quietly on a grille without getting shock, because of large area of contact, and by the fact that, in experiments on conditioned limb withdrawal from a grille, the animal may get no shock at all until it begins to make a response, at which time the shock may rise to maximum. In the latter case the very aspect of response receives punishment which should result in escape from punishment.

The discussions at the earlier Round Tables led three of the committee members to undertake to discover the relationship between

[2] This method has been very successful for the control of shock in experiments where attached electrodes (securing constant area of contact) were used. A number of individuals testified to this at the Round Tables. See, for instance, Muenzinger and Walz (4).

area of contact and threshold for perception of shock.[3] The results of these three independent investigations corroborated one another in most respects. Jackson and Reiss reported their study at the 1934 Round Table. They found that the current level had to be increased 4½ times to get the same shock when contact areas were increased by amounts comparable to the changes when using a grille (electrode diameters of 0.1 mm. and 5.0 mm.).

The above discussion describes the results of varying area of contact when the external circuit limits the maximum amount of current to a small value. When, on the other hand, an external circuit is used where the resistance is low and variations in stimulus are obtained by varying the voltage (as is the case with the inductorium as commonly used), the effects of variation in area of contact tend to be the opposite to those described. When such a circuit is used, the amount of current which passes will depend upon the resistance of the subject. But the resistance of any particular subject will vary with the area of contact: the larger the area of contact, the less will be the resistance. There is a rough proportionality between area of contact and effective resistance. Hence the total current passing will increase when the area of contact increases.

This second method of controlling the intensity of shock stimuli has been pretty universally rejected for exact work because of its dependence on the resistance of the subject. If different individuals vary in resistance (as they do), or if individual subjects change their resistance during an experiment (as they do), the method will have limited value as a precise experimental method. With respect to the latter factor it should be noted that stimulation of the skin by the current is followed by a large resistance drop so that there is an increase of current and therefore of stimulation.

The solution of the problem of the grille has not been found. Various methods of overcoming the difficulties introduced by varying area of contact have been suggested at the Round Tables, but they have either been impractical or in need of an experimental test. Among the latter the most promising suggestion appears to be the construction of a punctiform grille where each contact is as small as possible. If this grille were used in connection with a circuit which limited the total current, it would be necessary to have each point within the length of the animal supplied with current separately (through its own high resistance, for instance). This would prevent

[3] Jackson and Reiss (3), Forbes and Bernstein (2), and Muenzinger (unpublished observations).

the division of the available current between two or more points when these were simultaneously touched. The shock at each point of contact would then be independent of all other shocks. The unknown factor in this situation arises from the fact that, as the animal contacts more points, each of the separate shocks would summate with the others to increase the effect of the whole. The quantitative aspects of such summation need investigation.[4]

(2) *Physical and Physiological Problems.* (A) *Action of the Shock Stimulus.* The psychologist's use of shock is ordinarily in situations where the stimulating current is passed through skin to stimulate the afferent system. The current may therefore have its action by (1) the excitation of sensory end organs, (2) the direct excitation of sensory nerve endings, (3) the direct excitation of sensory fibers in a nerve trunk, (4) the direct excitation of motor nerves to cause a muscular contraction which leads to kinesthetic sensory discharge, and (5) the direct excitation of muscle tissue whose contraction leads to kinesthetic sensory discharge. The locus of action of the current will be influenced by the position of the electrode, the size, shape and composition of the electrode, and the type of current used. Therefore, in those cases where fixed electrodes are used, it is reasonable to expect that the placing of the electrodes be guided by a knowledge of the nature of the cutaneous and subcutaneous tissues. If it be desired to stimulate chiefly the deep tissues, large wet electrodes seem advisable. Experimenters should decide whether they wish to stimulate primarily skin or muscle and should select their method accordingly.

(B) *Electrical Characteristics of the Stimulating Circuit.* The committee section on physical and physiological factors called attention to the following relevant aspects of the stimulating current involved in its stimulating value. (1) The potential drop between the electrodes. This is the *voltage* and may be thought of on the analogy of pressure. (2) The current, *i.e.*, the total quantity of electricity flowing between the electrodes, measured by the *amperage.* The *power* is approximately the product of voltage $\times$ amperage and represents the energy expended or work done on the tissue. (3) The *form* of the wave of stimulating current. The duration of the rising phase and the rapidity of this change determine the stimulating ability

[4] Entirely apart from the problem of the grille, it was remarked that grilles have sometimes been used for experiments where an attached electrode with constant area of contact could have been used to much better advantage, thus avoiding many uncertainties.

of a current. As is well known, a steady direct current has relatively little stimulation value, even though it is doing work on the tissue. Direct current stimulation is usually attained by making and breaking the circuit.

We do not know the precise nature of the phenomena occurring on electrical stimulation of tissue, and we do not know the relation of each of the physical aspects of a current to its stimulating strength. At the 1934 Round Table there was a difference of opinion as to the relevant aspects of the stimulating current. One member felt that the shocking capacity of a current is completely defined by its amperage when a given electrode is in contact with a certain area of the body, and that other factors need be considered only in so far as they affect amperage (4). Others held that neither voltage nor amperage is the whole story, but that each is important (2). The latter group felt that each aspect of the current should be measured, if conditions are to be precisely reproducible.

The form of the stimulating wave in the tissue is not a stable physical phenomenon because the electrical characteristics of the tissue are not stable. The wave form will be determined by the following three factors. (1) The form of the impressed potential. Sinusoidal alternating currents and rectangular waves produced by interrupting a direct current are the more common. (2) The *inductance* of the electrical circuit, including the tissue. (3) The *capacity* of the electrical circuit, including the tissue. Inductance and capacity together determine the *reactance* of the circuit. This, combined with the resistance, gives the total impedance.

While the effects of inductance and capacity upon the electrical phenomena occurring in the circuit can be predicted, their influence on the stimulating strength of the current on skin have not been separately studied and cannot be predicted with assurance. Capacity is present in varying amounts when current is passed through skin, but what this does to the intensity of the shock on account of alterations in wave form is not known.

If we assume that the form of the stimulating wave and the voltage at the skin remain constant, then the amount of current flowing will vary with the effective resistance of the subject. Stimulation is usually secured by means of a changing current. The resistance to a changing current, however, is determined by a number of factors. In evaluating these factors, any current change can be analyzed into its component sinusoidal waves. An interrupted direct current, for instance, may be viewed as the limiting case, each make and break

corresponding to the rising and falling component in sinusoidal alternating current. The *effective resistance* (impedance) to a changing current will be different for each frequency, and will depend upon the ohmic resistance of the system (circuit and tissue) and upon its inductance and capacity (which will act somewhat like added resistance). The latter involves the back E.M.F. of polarization (battery effect). The resultant of these three factors is the impedance of the system.

The matters discussed above would presumably cause little trouble if they were constant factors. Unfortunately they are not constant, either with respect to different individuals, or in the same individual during an experiment. Individual differences might be compensated by measuring the electrical characteristics of each subject. But during an experiment there will be changes in resistance, capacity, and polarization resulting in alterations of effective resistance. Drying or sweating of the skin surfaces and local vasomotor changes will cause relatively large changes in all of these characteristics.[5]

(C) *Physiological Variables.* In addition to these largely physical aspects of tissue considered as a conducting substance, some physiological relationships were outlined to the 1934 Round Table by the committee section on those aspects of the problem. The stimulation value of a current will depend upon (1) the form of the stimulating wave, (2) the rapidity with which the waves are repeated, *i.e.*, the frequency of the impulses, and (3) the total number of successive waves or impulses (physiological summation). The optimum frequency of stimulation will presumably be a function of peripheral and central refractory phase. It may also be assumed that any alteration in these refractory phases will change the stimulation value of the current.

Other factors mentioned were: (1) the influence of size of electrode upon the locus of action of the stimulus, (2) the placing of the electrode with regard to cutaneous and subcutaneous excitable tissues, (3) local changes in tissue excitability (as distinguished from its electrical characteristics) due to changes in blood-supply, skin temperature, etc., and (4) general changes in the excitability of the subject.

(3) *Psychological Problems.* (A). *The Psychophysical Problems of Shock.* The psychophysics of electric shock might take a cue

[5] Muenzinger and Walz(5) have examined the relative merits of various stabilizing devices which have been used to minimize the effects of such changes.

from the psychophysics of sound where a unit of measurement (the decibel) has been adopted which makes it possible to achieve an easy control over the intensity of electrically generated tones. The decibel is a logarithmic unit which gives an expression of the ratio between two sound intensities. The unit is convenient because a change of one decibel is approximately the minimum change necessary to obtain a perceptible difference in sensation (1 db = approximately 1 j.n.d.). Actually the differential limen is sometimes a little more, sometimes a little less than the decibel, depending upon the frequency and the intensity level, but this variation is insufficient to disturb the practical value of the unit. The intensity of any tone can be expressed in terms of its deviation (in decibels) from the individual's threshold for hearing of the frequency under consideration. This deviation may conveniently be measured by using calibrated electrical resistances in the audiometer circuit.

It may be possible to develop some such scale for the use of electric shock. In order to do this, a study of the absolute and differential thresholds for shocks of different kinds must be made. This must be done under conditions where physical control of the circuits is adequate. It may need to be done separately for the various body surfaces and sizes of electrode which are used.

(B). *Psychological Variables.* The complexities of electric shock in its physical and physiological aspects are matched by equal complexities in its psychological aspects. The first problem to be met is that of the nature of the reaction to shock. Here must be considered: (1) its purely sensory aspects, (2) its reflex consequences, (3) its emotional consequences, (4) its reinforcing and interfering effects upon concurrent responses, and (5) its function as punishment in learning experiments. There are individual differences in reaction to shock, especially in its emotional consequences and its punishment value. In the field of animal work there are indications that, instead of functioning as punishment, shock may often operate as a distractor or as a general reinforcing agent. In a complete study of this problem the function of shock should be studied in various kinds of situations and for each species of experimental animal. A monkey, for instance, may react to shock in a manner quite different from a dog. In the case of humans we need more information about the consequences of shock as affected by individual differences, age, sex and race.

These problems of the consequences of shock are intimately related to the problems of the antecedents of shock. We know that

some subjects anticipate electric shock with a peculiar form of self-pride, while in others the situation is quite the opposite. The emotional disturbance preceding shock may in some cases exceed that to shock itself. Presumably these matters are a function of past experience. This experience with shock may involve factors of habituation (negative adaptation) and of conditioning against shock. A single shock of unnecessarily high intensity will cause a subject to over-react to subsequent shocks for a considerable period of time. Other antecedents which are known to influence the reaction to shock are relaxation, tenseness, expectation of shock, fatigue, euphoria, and competing reaction systems.

(4) *The Problems of Standardization.* While it is easy to make the statement that " Procedures in the use of shock must be standardized ", the Round Tables found it impossible to agree on any standard procedures which would meet with general acceptance. There were two reasons for this. In the first place, shock is used for many different purposes, so that a method which is suitable for one may be quite unsuitable for another. In the second place, there is as yet no universal agreement about the facts which are to determine the selection of a method, with the result that the selection of a standard by one group of individuals would be certain to meet with criticism by others.

Generally speaking, the differences of opinion about standardization were concerned with the following matters: (1) standardization of the type of current to be used and the devices to control this current (electrostimulators, electrodes), (2) standardization of the aspects of the current which shall be measured (voltage, amperage, wave form), (3) standardization in terms of a standard amplitude of response rather than in terms of a standard amount of current, (4) standardization by comparison of the stimulating strength of any particular current to the stimulating strength of some standard kind of current used as a measuring stick, and (5) standardization in terms of a scale of sensitivity related to individual thresholds for shock. We must wait for the advancement of knowledge by research before a safe decision can be made on most of the problems of standardization. For instance, referring back to the preceding discussion of the physical and physiological factors involved in the use of electrical stimulation, it becomes obvious that before we can wisely choose a " standard " method for psychological experiments, ***we must find the type of current which is least critical of the types of variation met with in sensory stimulation.***

The following points of view on some of these problems were expressed at the Round Tables:

(a) There was universal agreement that grille techniques should be improved before their standardization is attempted.

(b) There was universal agreement that the inductorium operated by a magnetic make and break in the primary circuit has no virtues for precise work.

(c) There was considerable feeling that 60 cycle alternating current should be adopted as a standard until extension of research offers a substitute. Others disagreed with this.

(d) Some argued that direct current should be adopted as standard because of its convenience. Muenzinger suggested the adoption of the amount of response to an interrupted direct current of certain characteristics as a standard measuring stick to which response to other currents could be compared. Taking 1.0 as the amount of current necessary to produce a certain shock by means of this standard of reference, Muenzinger and Walz (4) report the following equation of responses: 1.0 direct current $= \frac{1}{2\pi}$ half-wave rectified 60 cycle alternating current $= \frac{1}{\pi}$ full-wave rectified 60 cycle alternating current. They report that, when simple alternating currents are used, the physiological equivalence must be determined point for point.

(e) Darrow and Heath (1) have used as a standard the current just sufficient to tetanize the thumb to such a degree that the subject is unable to extend it against the shock. Large wet electrodes were used over the insertion of the nerve to *m. pollicis brevis*. The stimulating current was 60 cycle A.C. With the electrodes used, cutaneous shock was largely eliminated.

(f) There was considerable discussion which indicated that immediate efforts should be made toward standardizing shock in terms of a scale related to the threshold.

Conclusions of the Round Tables

While the Round Tables did not result in any formally stated conclusions on technical matters, the general temper of the groups is, in the judgment of the compilers of this report, expressed by the following statements:

(1) Electric shock is used so frequently in psychological experi-

mentation that it has become a matter of considerable importance to improve and standardize methods.

(2) Present practices in the use of shock are often inadequate for precise control of the stimulus intensity or for reproducibility by other investigators.

(3) Many of the problems in the use of shock are not in a stage where decisions on standardization can be made, but are problems for research. The papers read by the Committee at the 1934 Round Table indicated that active research is necessary especially along the following lines: (a) On the *electrical characteristics* of the stimulating circuits to determine the effects of the interposition of living tissues upon the stimulating current and upon its effectiveness. (b) A comprehensive program on the *psychophysics* of electric shock when using various kinds of stimulating current. (c) Research on the *psychological factors* involved in the use of shock. (d) Research having the *practical* object of testing the principles and applications of devices (grilles, electrostimulators) and methods suggested for standardization. (e) The development of devices to guard against *lethal shocks* and against shocks of unpleasantly high intensities. These must be of such simplicity that they can be used by those individuals, unskilled in electricity, in whose hands the use of shock is dangerous. They should furthermore be so inexpensive that they can be used by all.

(4) Although it was not strictly within the avowed limits of the group's task, there was considerable sentiment at the first Round Table that alternative techniques should be developed to take the place of shock. It was felt that we have perhaps been too ready in our acceptance of shock as a stimulus because of the simplicity of the devices which can be used, and that such techniques as the use of an air jet under pressure (directed against the side of an animal's head, for instance) merit more consideration.

Recommendations

In the preceding discussion have been indicated the reasons against specific recommendations at the present time. The compilers of this report feel, however, that the following suggestions are justified:

(1) Take precautions to avoid accidental lethal shock or shocks of unpleasantly high intensities. Following this report are papers by Lorge and Max (for the Committee) in which certain precautions are outlined.

(2) Do not use shocks of high intensity. In general, start with a *very weak* shock and increase it gradually until a satisfactory intensity is obtained. When used with animals, strong shock is unnecessary cruelty, and when used with human subjects may result in the placing of restrictions on the experimental use of shock in a way similar to the restrictions which have been placed on experimental work with hypnosis, sex, etc. While no such contingency has arisen over the use of shock, it should be remarked that the continuance of caution along this line is likely to entail no sacrifices, inasmuch as a moderate shock is ordinarily a more effective experimental stimulus than a strong one.

(3) Where possible, state all of the relevant items determining the strength of shock. (a) Type of current, source of current, nature of external circuit, and any special characteristics of the stimulating device. (b) Type of electrode. In the case of the grille, material of contacts, size and spacing; in the case of fixed electrodes, their nature, material, size and placing on subject. (c) Measurements of current with respect to both voltage and amperage. (d) Effective resistance of subject, changes in effective resistance, and current fluctuations resulting from these changes.

(4) State the physiological indicators used to determine the desirable level of shock, such as when the shock is related to the threshold, the use of a certain amplitude of finger withdrawal, questioning of the subject, certain characteristic reactions an animal makes when touching a grille, etc.

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PHYSIOLOGICAL ASPECTS OF LETHAL SHOCK

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In connection with the work of the Committee on the Use of Electric Shock in Psychological Experimentation whose organization is described in the preceding paper by Forbes, Muenzinger and Wendt (pp. 185 to 196) measures have been considered for the avoidance of the accidental administration of dangerously strong shocks. This task has been divided into two parts: (1) a search of the literature to discover the quantities of current which may be considered dangerous (undertaken by the present writer); and (2) an investigation of the protective efficiency of devices designed to limit the maximum possible shock administered to a subject (undertaken by L. W. Max; results presented in the paper succeeding this one, pp. 203 to 211). It is the aim of this paper to set forth the facts about lethal shock so as to indicate the surprisingly small quantities of current which may be potentially dangerous.

The physiological action of electric shock upon animal organisms depends upon many variables. Among the variables concerning which some information is available are: (1) current in terms of volts, amperes, and ohms; (2) type of current (alternating current or direct current); (3) frequency (alternating current); (4) duration of exposure; (5) nature of contact; (6) position of electrodes.

Prevost and Battelli have found that current is far more significant than voltage. These observations were confirmed in the later work of Weiss and of Zaçon.

Kouwenhoven and Langworthy (1930) experimented on the effects of electric shock on the central nervous system. They experimented on 286 rats using 110, 220, 500, and 1000 volts on alternating, and on direct current for varying lengths of time. In each series of experiments the duration of the shock was extended until resuscitation failed. Rats reacted in an entirely different manner on alternating current from on direct current. At lower voltages alternating current was deadlier than direct current, but at higher voltages the opposite was the case. In many instances rats were paralyzed by shock, and in a majority of cases gross hemorrhages were found in

the spinal cord at autopsy. All deaths in the rat were due to respiratory failure traceable to injury in the central nervous system. Direct current produces electrolysis of body fluids and some muscle contraction, whereas alternating current does not produce electrolysis but does produce severe muscle contraction.

Kouwenhoven and Langworthy report their data as follows:

Volts	Frequency	Effective Current Through Animal in Milliamperes	Average Bodily Resistance in Ohms	Duration in Seconds	Results (Death or Paralysis)
110	60 a.c.	26.5–47	3090	10–30	45%
220	60 a.c.	80–210	1890	5–35	72%
500	60 a.c.	240–490	1425	1–4	62%
1000	60 a.c.	700–1200	1140	1–4	71%
110	d.c.	28–53	2685	5–60	15%
220	d.c.	100–200	1635	5–30	47%
500	d.c.	280–460	1385	1–4	48%
1000	d.c.	—	1365	0(?) –4	73%

Hooker, Kouwenhoven and Langworthy (1933) found in general that ventricular fibrillation is not induced by large currents. Death occurs through respiratory failure in the case of large currents, but in the case of low voltage shocks death is due to ventricular fibrillation.

In the case of man, according to Kouwenhoven and Langworthy, deaths have been recorded at 3 or 4 m.a. In general, however, they estimate 25 m.a. a minimum for death. Weber took 35 m.a., A.C., at 50 cycles, between his hands without any after-effect save occasional burns when the area of contact was small. Shocks at 35 m.a., A.C., were extremely painful and could be borne only for a second or two. Trotter, wetting his shoes, standing on a running rail and grasping a trolley wire, endured a 600 volt direct shock of approximately 35 m.a. for a few seconds. Trotter believes that alternating current is four or five times as painful as direct current. It might be of interest to review the protocol of Dr. H. F. Weber who set himself the problem, " How high must the alternating voltage be to be considered dangerous to human beings? " He used an A.C. of 50 cycles with potential differences from 10 to 630 volts. His protocol is as follows.

Effective Current Through Body in

Volts	Effective Current Through Body in Milliamperes	Electrode Position	Type	Results
10	< 1	Grasping wire leads one to each hand.	Wire damp.	Very slight muscle vibration in fingers.
20	2–2.4	" " "	"	Very strong muscle and nerve vibration in fingers, hand and joints of hand, up to the forearm; strongest effects in joints of hand; hands and arms still freely movable; the wire can still be released easily.
30	12–15	" " "	"	Fingers, hand, joint of hand, forearm and upper part of arms as though paralyzed; fingers can hardly be moved; hand can barely be turned; outstretched arm can no longer be bent; bent arm can no longer be straightened; very active pain in fingers, hand, and arms; this condition is bearable only 5–10 seconds.
40	19–22	" " "	"	In grasping the wires, the fingers, hands, and arms are at once completely but temporarily paralyzed, an almost unbearable pain setting in; beyond five seconds the pain is unbearable; the wires in all cases can barely be released.
50	Pain prevents measurement.	" " "	"	All muscles in fingers, hands, and arms immediately paralyzed; the wire could in no case be released; pain can be endured but 1 or 2 seconds.
10, 20, 30	——	" " "	Wire dry.	None, or weak physiological effects.
40	Too weak	" " "	"	Slight buzzing in fingers.
60	Circa .8	" " "	"	Lively vibrations in the fingers, hands, and forearms, but all these organs easily movable.
70	1.8	" " "	"	Strong excitation of muscles of fingers, hands and arms beyond elbows; these organs slightly movable.
80	9–11	" " "	"	Fingers, hands, arms practically stiff; active pain in all of these parts; the wires can be released only with utmost effort.
90	Pain prevented measurement	" " "	"	Total paralysis of hands; impossible to release wire; pain extremely intense; crying aloud; can be endured but 1 or 2 seconds.

Weber did not attempt a trial of the effects at 100 volts, due to the enormous increase of the effects in the transition from 80 to 90 volts. After his experiments, his belief is: "Grasping two alternating-current leads, with both hands, in a dry condition, involves danger as soon as the voltage difference between these leads rises beyond 100 volts."

Duchosal set himself the question of "Why is death caused in guinea pigs at some times and not at others by a shock of less than one second duration at 50 cycles?" He found that at 50 volts, A.C., and durations of less than 0.3 sec., no fibrillation of ventricles occurs. At durations between 0.4 and 1.5 sec. the following effects occur: (1) immediate resumption of normal cardiac rhythm; (2) ventricular fibrillation lasting from several seconds to a few minutes and finally a slow return to normal rhythm; and (3) death through ventricular fibrillation. These three effects are independent of individual differences. The exact instant of the current arrival at the heart does not seem to be related to the effect.

Jellinek states that death occurs from a passage of 100 m.a. through the body. Currents of 70, 80, or 90 m.a. cause disorder in heart rhythm. It is apparent, and statistics bear this out, that there is considerable variation in susceptibility to shock. Deaths have occurred from currents of 3 or 4 m.a. to currents in excess of 100 m.a. Death by electrical shock is due to the disturbance of normal heart rhythm (ventricular fibrillation) or to the inhibition of the central and peripheral nervous system, including cardiac inhibition. Shocks at low current may result in death from asphyxia, even when the heart is unaffected. There is a marked variation in the reaction of individuals within the same species to electrical shock, and even in the same individual with repeated shocks. It is important that experimenters using electrical shock acquaint themselves and their co-workers with the Prone Pressure Method of Resuscitation. Knowledge of this method may be of value in cases of asphyxia.

The experiments of Kennelly and Alexanderson are of importance in the study of alternating currents of higher frequencies. With both hands immersed in saline, they report the following shocks as just bearable: 8 m.a. (5–6 volts) at 60 cycles; 30 m.a. (12–20 volts) at 11,000 cycles; and 800 m.a. (200–360 volts) at 100,000 cycles.

D'Arsonval as well as Thomson report that man can bear up to 3 amperes without discomfort at frequencies from 10,000 cycles to 1,000,000 cycles.

The question of the "Elektrisitätswerken des Kantons Zurich",

"What constitutes an electric current dangerous to man?" is of interest here. They set the criterion as "that intensity in which the person in question can no longer let go of the electrodes". This value is 15 m.a., A.C., which is less than half that borne by Mann and Weber. We feel that for normal use in psychological experimentation a limit of 12 m.a. will allow a 25 per cent margin of safety. This tentative standard of 12 m.a. is not arbitrary. The protocol of Weber shows that when hands were damp, 12–15 m.a., 30 volts, was the current at which the fingers could just barely be moved; and when hands were dry, 9–11 m.a. at 80 volts resulted in the same condition. Another reason for the adoption of the 12 m.a. standard is that Spence and King, in a private communication, have indicated that (a) the greater the stimulating current, the greater the decrease in bodily resistance, and (b) the greater the duration of electrical stimulation, the greater the decrease in bodily resistance.

With the tentative adoption of a 12 m.a., alternating, 60 cycle current as maximal, it is further imperative that no vital organ be in the pathway of the current. Contralateral stimulation such as that used by Tolman, Hall, and Bretnall, and later duplicated by Muenzinger, might involve the heart in its circuit. Kouwenhoven, Hooker, and Langworthy (1932) found that 9 to 10 per cent of the total current passing through the body flows through the heart for a current pathway parallel to the body axis. When the current flows transversely only about 3 per cent passes through the heart. Thus as far as the heart is concerned fibrillation will be produced by a much smaller total current flowing from the upper to the lower extremities than between the forelegs. In most industrial accidents the current path is from right hand to the feet and under those conditions the heart carries a greater proportion of the total current than when contact is made in any other location of the body. This is due to the fact that the current is grounded through the feet.

These tentative criteria have been the basis for the Committee's search for protective devices and suggested precautions.

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PROTECTIVE DEVICES AND PRECAUTIONS AGAINST LETHAL SHOCK*

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Since the amount of electrical knowledge on the part of experimenters working with shock apparatus is a variable factor, the safest solution of the lethal shock problem would seem to be the incorporation into the shock apparatus itself of some fool-proof device which would automatically protect the subject from dangerous intensities of current. We have accordingly considered and experimented with three types of protective devices: (1) fuses, (2) mechanical relays, and (3) vacuum-tube devices. The study of these devices is not yet complete, and this is to be regarded merely as a tentative report.

The nature of the best device will depend partly upon the type of stimulating current used: a protective circuit, for example, which provides only D.C. or rectified A.C. would be virtually useless if pure A.C. were desired for the shock. Since no one type of shock has been made standard, we investigated possible protective devices for all kinds of current.

Requirements

The ideal protective device must meet three requirements: (1) it must operate smoothly and unfailingly at the pre-determined cut-off current; (2) this operation must be sufficiently rapid, since the duration factor is an important one in lethal shock; and (3) the cut-off action must never occur below the prearranged maximum, as this would interfere with experimentation. Since the quantitative evidence thus far available is of a more or less anecdotal nature, and the physiologically safe limits both as to time and intensity have not yet been satisfactorily determined, we recommend as provisional maxima 12 m.a. and 8 sigma (½ cycle of 60 cycle A.C.), these values being

* This paper was prepared in connection with the work of the Committee on the Use of Electric Shock in Psychological Experimentation, whose organization is described in the preceding paper by Forbes, Muenzinger and Wendt (pp. 185 to 196). The physiological aspects of lethal shock are discussed in the preceding paper by Lorge (pp. 197 to 202).

subject to subsequent increase when justified by further experimentation. This means that an adequate safety device must eliminate all currents above 12 m.a., and that this elimination must take place within 8 sigma after the onset of the stimulus. The 8 sigma limit is but a small fraction of the threshold shock-duration reported by Duchosal as producing ventricular fibrillation in the animal heart, and thus affords a good margin of safety; as ½ cycle A.C. it also provides a convenient electrical parameter for specifying and checking the speed of A.C. protective devices. These provisional standards are recommended for normal *adults* only; there is some reason for believing that children have a lower tolerance for electric shock. The implication of some of the animal work (Dunlap) is that a lower maximal intensity may be necessary for women than for men, but the 12 m.a. limit will probably take care of such a sex difference if it exists.

1. Fuses

The protective possibilities of both commercial and laboratory-made fuses with a blow-point at or about 12 m.a. were investigated. The commercial fuses were found unreliable as at present designed, the home-made ones being more satisfactory.

(a) The only commercial product suitable for this application is the 1/100 ampere fuse recently developed for protection of electrical meters. Two dozen of these fuses were purchased in the open market and their blowing-points experimentally determined. One of them blew at 14 m.a. and all the rest at currents above 15 m.a., while one failed to function until 36 m.a. was reached,—a degree of variability which is prohibitive. Recently, an additional two dozen of new mechanical design were tested. Of the twelve 1/100 ampere fuses tried, one blew at 7.5 m.a., two at 14 m.a., three at 15 m.a., two at 16 m.a., one at 17 m.a., one at 18 m.a., one at 19 m.a., and one at 20 m.a. Because of this poor performance, an oscillographic check of the time factor was not made; but, as judged by the throw of the milliammeter needle, the speed of blowing varied from less than 1 sec. to 12 sec. A dozen of the new 1/200 ampere fuses were similarly tested but were found highly erratic in action. There was indication that, as at present designed, this type of fuse might not only fail to protect at a critical moment but may actually produce secondary surges of an objectionable, if not potentially injurious, magnitude. Our conclusion is that these commercial fuses fail to meet our protective requirements, both as to speed of action and reliability of cut-off.[1]

(b) Laboratory-made fuses of more careful design show more promise. In an earlier study of the possibility of preparing a fuse for protecting gal-

[1] In fairness to the manufacturers, it should be mentioned that these fuses are primarily designed for meter-protection and not to meet the stringent specifications here set up.

vanometer-strings in the Einthoven galvanometer, it was our experience that reliable fuse-action can be attained at a level of 6 m.a. or above. Various fusible alloys and unimetallic wires were drawn down by the Taylor and Wollaston processes into the form of very fine wire; fuses were then constructed of this fine wire and their blow-points investigated. The results can be only briefly mentioned here. The finely drawn fuse-alloy proved unsatisfactory, both because of the difficulty of handling and because different sections of the same length of wire yielded differing fusing-points. The unimetallic wire gave greater constancy of performance, six individual fuses made from one length blowing at 5¾ to 6½ m.a.

The fragility of these fine filaments and the tedium of constructing reliable fuses from them, incline us against advising each experimenter to "roll his own". If there is sufficient demand for them, we would be willing to engage someone to prepare a quantity of them under our direction, to be supplied at cost. Or, as an alternative and preferable solution, an authorization to place a special order with a commercial firm for 1 or 2 gross would render more likely our getting them built to the more stringent electromechanical specifications necessary for protection against lethal shock. They could then be ordered directly from this manufacturer.[2]

2. Mechanical Relays

Another possible solution to the lethal shock problem would seem to be a mechanical relay with sure-fire action under the duration and intensity requirements above outlined. Such a relay would avoid the inconvenience of fuse-replacement, and the danger attending erratic blow-points in different fuses of the same nominal rating.

Nine relays of varying manufacture have been tested and oscillographic records made of their action in electro-stimulator circuits. These oscillograms showed that in all 9 instances the manufacturers' claims as to speed of action have been exaggerated, reliable action within 1 cycle being obtainable in some cases only with an overload of several hundred per cent (in one case, 1200%).

Under conditions of marked overload the most satisfactory relative performance thus far was obtained from a Weston Type 30 D.C. relay. This has a rated period of 0.45 sec. and an actual one of 0.75 sec.; but under overload the oscillograms showed that a deflection can be obtained in 1/60 sec. (The galvanometer circuit was operated by the voltage-drop across a fixed resistor in series with the subject; in the A.C. set-up this potential was rectified.) Because of the necessity of overload, we feel this relay fails to solve the

[2] Since this report was written, the Littlefuse Laboratories, of 4507 Ravenswood Avenue, Chicago, have agreed to manufacture fuses of the laboratory type above mentioned. Inquiries or orders should refer to special fuses for shock apparatus and should be addressed directly to the company.

problem, even if operation within the required 1/120 sec. were attainable. The other relays proved to be either uncertain in cut-off action below 15 m.a., or insufficiently rapid, or both.

We have no single relay as yet which can be recommended as completely safe, and are still in communication with several manufacturers, two of whom have been constructing special units and submitting them to us for test. In the meantime, we have been experimenting with a home-made device which, as the oscillograms show, operates within the first cycle of an impressed current of 14 m.a., but which still needs further modification.

3. Vacuum-Tube Devices

The present inadequacies of the above mentioned fuses and relays can be largely overcome by the vacuum-tube approach. The vacuum-tube is instantaneous in its action, and by proper selection of operating voltages our intensity requirement is easily met. The tube-circuit can be designed with an adjustable cut-off, which can be set for different levels, according to varying experimental needs. The possibilities of 5 types of tube-circuits have been considered.

1. The circuit described by Muenzinger and Walz (3) for controlling resistance variations might also be utilized as a protective device for D.C. stimulation. From the lethal shock viewpoint, however, it has the disadvantage that the tubes on which that circuit is based would themselves be unsafe if used at the maximal intensity requirement adopted. Thus, to obtain 12 m.a. with the type 58 receiving tube suggested for use with human subjects, would, according to Muenzinger and Walz's calculations (pp. 480–481), require a plate E.M.F. of 1300 v.! Since the maximum plate voltage recommended for this tube by its manufacturer is only 250 volts, so high an overload cannot be considered for an application where safety is the prime objective. It will be recalled that the larger transmitting tubes frequently break down even when operated at their *rated* maximum voltages; such breakdown would be more liable to occur with a 500% overload of the less rugged receiving tube. One electrical accompaniment of such a breakdown is an abnormal increase in plate-current due to ionization of the residual gas, and a current-increase sufficient to destroy a tube is one to which a human subject should not be potentially exposed. We have accordingly investigated the performance of a somewhat similar circuit built around the 865 transmitting tube which is designed to withstand much higher voltages than the 58; in this circuit raw A.C. was utilized for the plate-supply in place of the power-pack, the general use of which is to be discouraged where human subjects are involved. While this modified arrangement has possibilities, its study was not further pursued when it became apparent that the resistance-control was not as good as that indicated for the smaller tube.

2. For the past two years, the writer has been using the protective circuit of Fig. 1 with human subjects. This circuit makes use of the plate saturation characteristic of the tube, which operates as a half-wave rectifier. Adjustment of the filament emission by means of the rheostat F determines in advance the maximal stimulating current delivered to the subject; this current is read upon the milliammeter M. Once this adjustment is made, a further increase in the applied voltage (due to line surges, etc.) cannot significantly increase the stimulating current, as can be seen from the figures in the accompanying table.

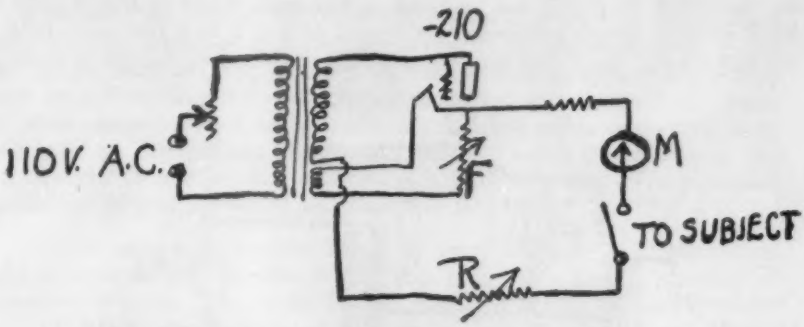

FIG. 1. VACUUM-TUBE PROTECTIVE DEVICE FOR D.C. SHOCK (HALF-WAVE RECTIFICATION)

In taking these measurements, the filament was supplied with A.C. A better cut-off action is obtainable with a filament battery, but even with the simplified circuit shown, the regulation was satisfactory. At the laboratory, we employ a storage-battery; when the electrostimulator is used outside the laboratory, the 5 volt filament winding and the 800 volt secondary winding of the transformer are employed. As can be seen from the table, at these settings the stimulating current will remain at 10 m.a. even if a surge should increase the plate voltage by as much as 200 volts.[3] Submaximal variation of the stimu-

PROTECTIVE ACTION OF VACUUM TUBE DEVICE OF FIG. 1

(Ef=filament voltage; Ip=stimulating current in milliamperes at varying transformer-voltages)

Ef volts R.M.S.	Ip m.a. at 350 v.	Ip m.a. at 425 v.	Ip m.a. at 500 v.	Ip m.a. at 700 v.	Ip m.a. at 850 v.	Ip m.a. at 1000 v.
3.5	.8	.8	.9	1.0	1.0	1.0
4.0	2.0	2.0	2.1	2.5	2.5	2.5
4.5	4.5	4.5	4.6	5.0	5.0	5.0
5.0	8.0	8.0	8.25	10.0	10.0	10.0
5.1	9.0	9.25	9.5	11.0	11.5	11.5
5.2	9.5	10.25	10.5	12.0	12.75	13.0
5.3	10.5	11.25	11.5	13.5	14.5	15.0
5.4	11.5	12.25	13.0	14.75	15.75	17.0
5.5	12.5	13.25	14.0	16.5	17.5	18.0

[3] The underlying principle of the present circuit, plate saturation, is not the same as that of T. H. Howells (1).

lating current is provided by the control R. While the type 10 tube, which has stood up well under extended use, is here indicated, similar cut-off action has been obtained with other power tubes, and also with rectifiers. Where a tube is to be specially purchased for such a circuit, we advise a larger transmitting-tube (such as the 203A, which is rated at 1250 volts and is now designed to carry 100 watts).

3. The limitation of both the foregoing circuit and that of Muenzinger and Walz is that neither yields A.C. For this reason, we have recently substituted for the circuit of Fig. 1, the push-pull arrangement shown in Fig. 2. The latter circuit is simply a Siamese-twin version of Fig. 1, each tube controlling one-half the A.C. wave, and both halves being recombined by the output trans-

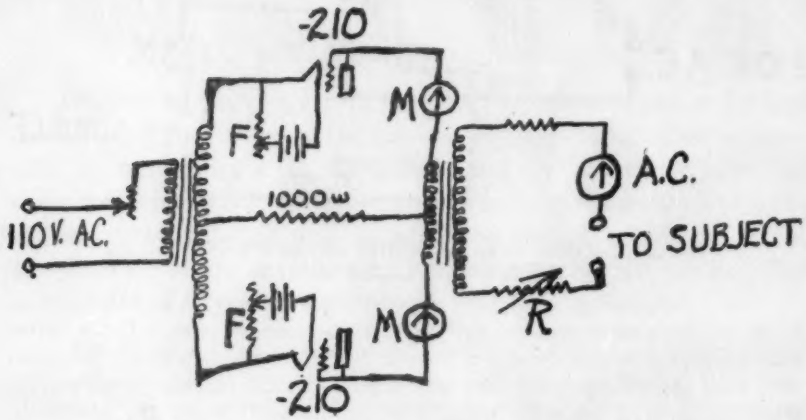

FIG. 2. VACUUM-TUBE PROTECTIVE DEVICE FOR A.C. SHOCK, WITH ADJUSTABLE CUT-OFF

former into full-wave A.C. Both the D.C. milliammeters M are set to the same reading by the filament rheostats F (thereby compensating for any inequalities in the tubes), and the desired maximal shock-intensity is read on the A.C. milliammeter in series with the subject. Further submaximal variations are supplied by R. As an added safety factor, the tubes in this circuit are operated at considerably lower plate-voltages than the manufacturer's maxima; this is more than compensated for in the step-up plate-transformer, which also provides a constant load for the tubes and smooths out the A.C. wave-form. It may be possible to supply the filament-current by two low-voltage transformer-windings or even to employ a single tube with a double plate, but we have not yet investigated the effect of such a step. The current-regulation is at least as good as that of Fig. 1, and we regard this push-pull arrangement as the superior device of the two.

Other vacuum-tube arrangements considered but not yet investigated are the following:

4. Use of single tube, or a pair in push-pull for straight amplification of the full-wave 60 cycle A.C., but with the tube voltages so selected as to choke

down the A.C. output when it rises beyond a predetermined value. One type of circuit for accomplishing this result is that described by the writer for protecting galvanometer strings in the Einthoven galvanometer (2). For protective purposes rugged tubes of the transmitting type should be selected as the amplifiers. Where an amplifier arrangement is used to achieve the cut-off, it would be feasible to utilize the output of a 1000-cycle oscillator instead of 60-cycle A.C., and thus derive the sensory advantages of the higher frequency of alternation.

5. Shunting the subject's circuit with a gaseous discharge tube so arranged as to ignite or flash-over when the current reaches the maximum value. Once the ignition point has been exceeded, the tube will divert most of the current from the subject, since these tubes have a negative resistance-coefficient. Some of the newer neon glow-tubes with adjustable ignition-points would seem to be promising for this purpose. By locating the tube where it can be seen, the experimenter is supplied with a visible warning of overload. The protective possibilities of grid glow-tubes should also be investigated.

Vacuum-tubes as a possible source of error. Should A.C. stimulation become standard, vacuum tube devices may conceivably become a source of experimental error. For, to be strictly comparable, all quantitative results would then have to be expressed in terms of pure sine wave-forms. Since vacuum-tube circuits are a fruitful source of wave distortion, the A.C. transformation-ratios between maximum, R.M.S. and average values, etc., will not strictly apply. Just how serious such error might be, one cannot predict, depending as it will on the nature of the vacuum-tube circuit and the manipulative skill of the experimenter; but its magnitude may conceivably become more than negligible in studies involving threshold measurements.

Of the vacuum-tube devices investigated, the one which best meets our requirements is that of Fig. 2. As regards expense, a complete stimulator circuit built around this device would cost less than present electrostimulators. Its chief disadvantage is that its underlying circuit is more complicated than a fuse or relay circuit would be. But the manipulative adjustments required are rather simple, and could easily be made even by a non-electrically minded experimenter, by following a set of operating instructions.

Conclusion

The unfinished nature of the present study was mentioned at the outset, and we do not as yet feel justified in advising one type of protective device to the exclusion of the others. The safest solution may be a combination of two of the devices. We hope to have a more definite recommendation in our next report. In the meantime, for work with humans, the old stand-by of a large resistance in series with the subject should be retained.

Suggestions on Design of Shock Apparatus

Regardless of which protective device proves most adequate, the design of shock apparatus needs improvement. All live and exposed connections with which an operator may come in contact or which may be short-circuited by an accidentally dropped screwdriver or metal pencil should be eliminated. Experimenters, for example, have reported unpleasant shocks from exposed studs and tap switches in the Jenkins box. The separable connecting cord to the 110 v. line, used in the latter apparatus, has itself been a source of shock when its line-end was plugged in before the box-end. The substitution of motor receptacles and plugs would eliminate this cord difficulty. (The current output of this circuit is inadequate, the writer having found it necessary in his own work with humans to utilize the full 12 m.a.) Since, for the present, large series resistors are the subject's chief protection, these should be wire-wound, and of high current-carrying capacity. They should not be of the carbon or lavite type, as in the Dunlap stimulating circuit; with a current of several milliamperes these resistors will heat up and because of their negative resistance-coefficient may, when working near the 12 m.a. limit, increase the current through the human subject beyond desirable limits. All circuit connections should be made mechanically secure before being soldered, and acid-core solder should be avoided. Finally, every designer of a stimulating-circuit should first familiarize himself with such publications as the National Electric Safety Code (4).

The writer has designed three inexpensive electrostimulators which avoid such defects and which have been in successful use with human subjects. Further details will be supplied on request.

General Precautions

Even the most ideal of protective devices cannot substitute for the exercise of care in the use of shock apparatus. For the operator's protection, it is recommended that only one hand be employed in the manipulation of the controls in present high-voltage apparatus. In locating the shocking electrodes on the subject, avoid all contralateral leads (*i.e.*, from one side of the body to the other), or ipselateral leads above and below the heart (such as right hand to right foot). Where possible, electrodes should be firmly fastened to the subject, especially when intense shocks are contemplated, as the subject's "startle" responses may dislodge an electrode and throw it into

contact with a body part to be avoided. The subject might well be insulated from the ground, by means of a rubber mat or glass casters, particularly where the floor is of cement or composition. Finally, every experimenter using shock apparatus on human subjects should learn the Shaefer method of resuscitation.

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IMAGINATION

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This review is concerned chiefly with the experimental literature on imagination. The material is not presented in chronological order; the order of presentation corresponds, however, to the differing emphases of successive periods in the development of the psychology of imagination. A brief survey of theoretical discussions and practical aspects of the psychology of imagination is also included.

I. Imagery Studies

Much of the earlier research on imagination was concerned with the definition of imagery types, images of imagination, and the meaning of imagery. Baird's (7) reviews cover many studies of this kind. The investigations reviewed here deal with imagination in general rather than in the sense of image-forming, with "testing" of imagery types, and with controversial findings on the nature of imagination.

Imagery Types. Burnham (14) describes and defines reproductive imagery types: tactiles, few in number, found mostly among the blind; visuals or Eidetiker, first described by Galton in the breakfast table experiments; audiles, exemplified by rapid calculators; motor types; and normal or mixed types. Burnham describes the Jastrow test used in determining imagery dominance: accuracy of retention of nonsense syllables or prose when heard is compared with retention of similar material when read. Burnham finds that American schools encourage visual imagery only, especially in language study, by their emphasis on vision rather than on both vision and hearing. Manual work is recommended for the development of motor imagination.

Bowers' (10) pupils were asked to rate words of a scale of 4 according to the vividness of the auditory imagery aroused; identical lists were given a week apart. The correlation between ratings on test 1 and 2 was .86. Catch words were included, such as *yet, that, was,* etc. The mean correlation between 20 alternate ratings was .71. Bowers' study indicates that some degree of reliability may be obtained from ratings of imagery. Carmichael (17) recommends the use of the Binet design from memory and of the Binet pictures as

tests of eidetic imagery. Rapid and unhesitating reproduction or description suggest the eidetic type. Visual imagery dominance and number forms were found to be associated in Chalmers' (**18**) subjects. Brittain (**12**) observed that boys, in general, were motor types, whereas visual and auditory types predominated among girls. Queyrat's (**75**) treatise deals with the various imagery types at great length.

Stetson (**86**) gives further details of the Jastrow tests: span experiments test the limitations of sight and hearing in perception and the amount and nature of error in each sense; two perceptual processes in different modalities carried on simultaneously are rated for accuracy of impression. Stetson sent a questionnaire to 100 college juniors who were required to observe imagery in dreams, to recount methods of recall, to describe breakfast table imagery for color, form, size, etc., to report methods of memorizing music, to introspect and describe on conceiving the words *toddle* and *bubble* with open lips and passive tongue, to indicate extent of articulation in reading, etc. Eighty-two reported that they were visual types; 41 had number forms. Tactual images played a minor rôle. Twenty-five used auditory, 23 tactile, and 35 visual imagery in memorizing music. In commenting on this finding, Stetson notes that Beethoven was deaf. "Facility in image thinking", it was concluded, "must enhance aesthetic appreciation if it is not essential to it".

Peers (**72**), in a study of the relation between imagery and comprehension of literature, does not substantiate this conclusion. Is the use of imagery by the teacher profitable, and if so, how can the teacher control the pupil's imagery? The subjects, boys aged 13 to 17 years, were tested for imagery type by descriptions of the breakfast table, of the odor of roses, of descent in a lift or into a tube, and of an express train in motion—tests of visual, olfactory, motor, and auditory imagery, respectively. The instructor read passages from Dante and Shakespeare, stressing the imagery. The subjects were then tested for grasp of the passages. Peers found that stress on imagery may be valuable in teaching but may obstruct the understanding of literature in which the meaning is contained in the imagery. When the meaning does not lie in the imagery, stress on imagery interferes with both interpretation and comprehension.

Similar methods were used by Colvin and Myers (**21**), who conducted an experiment with 520 pupils aged 8 to 20. Visual imagery was tested by memory for letter squares, and motor imagery by ability to memorize verbal material with the tongue between the

teeth. In testing auditory imagery, memory for nonsense syllables seen was contrasted with that for nonsense syllables heard. The parts of a story with varied imagery recalled after an interval was used to determine imagery type. Visual types, it was found, predominated in the lower grades and decreased as motor and auditory types gained in numbers. Verbal imagery increased in the higher grades, probably because of concentration on verbal material. A decrease in richness of imagery was noted before puberty; after puberty verbal imagery increased. Relatively little motor "imagination" was observed. Imagery type apparently determined retention patterns: auditory types recalled heard material, visual types recalled seen material, etc. In another study (22) Colvin and I. F. Meyer found that all types of imagery, except the visual, declined before adolescence. Lay (57) compared the imagery of 120 artists with that of 100 college students and concluded that "the possession of the creative imagination implies that of mental imagery, but not *vice versa*".

Davies (25) criticized Titchener's statement that definite and clear images become images of imagination by the "feeling of strangeness" and by the absence of definiteness, and questioned the distinction between image and sensation. Titchener (90), replying to Davies, contended that sensation and image are not clearly differentiated and may be confused (*cf.* Perky's results, reported below); reproductive imagination is based on memory while creative imagination starts with recollection and functions by means of search and thought.

Images of Memory and Imagination. Perky's (73) study is prefaced by a summary of the numerous connotations of the word imagination. Imagination is used as a synonym for visual imagery, hypothetical situations, hallucination, visionary tendencies, abstraction, ideation, etc. Psychology discusses imagination under the varied rubrics of thought, feeling, will, memory, image, and representation.

Perky's subjects were asked to imagine certain objects and to project the imagined image on an appropriately colored screen. A faint picture of the imagined object was shown on the screen during the reverie. Thirteen- and fourteen-year-olds believed that the projected image was subjective. One boy of 10 reported that the image was real, probably, Perky asserts, because of noise made by the projection apparatus. Only 3 of 27 adult observers did not accept the illusion, again because of technical errors. The adults accepted the

ruse in spite of such seeming inconsistencies, as revealed in introspection, that the imagined object, say a leaf, did not correspond to the projected image of a leaf of a different variety. Perky concluded that distinct "images of imagination" existed.

Further experiments, with adult subjects, were conducted to discover the differentia of images of memory and imagination. Introspections for various stimulus words and sentences were reported. In another set up, the subject was required to fixate lighted spots on a card. All of the subjects reported that images of imagination required steady fixation of the lighted spots. Records of facial and laryngeal movements were made during silent introspection of auditory and olfactory images. Movement was found to distinguish memory images from images of imagination. The percentages of memory images showing movement were as follows: 89.5 for visual images, 94.0 for auditory images, and 96.0 for olfactory images. The percentages of imagination images which did not show movement were 79.5, 91.0, and 80.0, for visual, auditory, and olfactory images respectively. Perky concluded that more decisive results might have been obtained had only experienced observers been employed. Other conclusions were that imagination images were stable, were accompanied by an unpleasant mood, and lasted for a long time.

Perky's results were contradicted by Ogden (67), who investigated the differentia of visual images of imagination and memory. Fifty words were presented visually one at a time on a card so arranged that the field of vision contained only the printed word while fixation was perfect. The subjects reported their introspections aloud. Half of the words were chosen to arouse memory images and half to arouse images of imagination. Kinaesthesis did not distinguish the memory images, as Perky found, although the set-up was unfavorable for corroboration of Perky's findings. On the other hand, Ogden found that images of imagination were definite and often had personal reference. He concluded: that visual memory images and eye-movement are uncorrelated; that both images of memory and images of imagination are localized; that memory images are usually localized in the distance; that color does not differentiate the two types of image; that affective patterns are infrequently reported and usually in conjunction with memory images; that memory images are more spontaneous and distinct than images of imagination; that the reaction time for them is less; and that more associations appear with imagination images. Ogden con-

cludes that there are no experimental differentia of images of memory and imagination.

Perky's results were also contradicted by Martin. Titchener (91) defends Perky's findings on the grounds that Perky did not require her observers, as did Martin, to classify images as imaginative or mnemonic, and therefore avoided the effects of suggestion.

Brittain (12) reviews the findings of several authors. Malebranche's results on the unimaginative nature of women, Dilthey's theory of the analogy between the poetic and demented mind, and Egger's theory of memory as the substrate of imagination are discussed at length. Ribot considered symbolism an incomplete type of affective imagination and self-feeling as the instigator of the motor elements fundamental to invention (see Jacobson's work, reviewed below). Brittain concluded, from his review of previous work, that the term imagination may be applied to a variety of intellectual products, that the faculty theory of imagination did not fit the facts, and that imagination and the affective processes are closely related. Brittain contrasts the definite memory image with the image of imagination in which new meanings are discovered. Association by similarity is characteristic of imagination and phantasy.

Other Characteristics of Imagery. The kinaesthetic nature of some forms of imaginative activity are demonstrated by the physiological researches of Jacobson (47). He found that a relaxed adult subject, when imagining the bending of the right forearm, reproduced movements on a recording device similar, though on a smaller scale, to those produced when the actual movement took place. The results were negative when the subject imagined movements of other parts of the body or was merely relaxed. Positive findings were found, under similar conditions, in the case of movements of other limbs and in the case of eye movements. No neuromuscular activity was recorded during completely relaxed states, but thinking or abstraction was found to be accompanied by measurable movement of the speech musculature.

Certain aspects of Dearborn's (27) study indicate similar findings. He asked 19 adult subjects to introspect about the feelings aroused by the imagined receipt of money in sums up to $100,000. He concluded that joy caused movement, expansion, and extension of the body, even in a hypothetical situation, but on imagining the receipt of larger sums the subjects' movements were inhibited. The responsibility entailed by large amounts of money probably accounts for this, according to Dearborn.

The types of imagery found by Henning (43) were classified as fixed, moving, mixed, etc. Anygal (4) used 16 university students as subjects in investigating differences in orientation imagery. The subjects were required to draw plans for reaching a certain part of the city from a certain fixed point. Anygal found that one group of subjects pictured themselves as oriented from their immediate location, while another group presupposed a fixed point from which the plans were drawn, without reference to immediate location.

II. General Experimental Aspects of Imagination

In addition to the techniques already described, a wide variety of materials and methods have been used in the study of imagination. Whipple's (97) *Manual* lists over a half dozen different test materials for which norms have been obtained. Whipple defines imagination as imaging; more broadly, as thinking images into new patterns. Spontaneous imagery in phantasy and capacity for creative imagery are measured by such devices as ink blots, used with or without a fixed time interval for report; forming a fixed number of words into sentences; combining two words, a noun and a verb, with a "point" in a sentence; sentence completion; building stories around words; theme writing; word building; insertions and completions; and interpretation of fables.

Investigations which include the use of the ink blot as whole or part of a test of imagination will be considered first. Historically, this was the first technique to gain widespread use in the quantitative study of imagination.

Ink Blot Studies. Dearborn (28) studied 16 adult subjects, averaging 35 years of age. The subjects looked at the blot and tapped to signify the appearance of an image. They were instructed not to allow the image seen in the blot to separate. Twelve sets of blots, 10 blots per set, were presented, and the experiment was postponed in the event of fatigue. Average reaction time was 10.3 seconds. The two artists and two poets were superior to the other subjects. The slowest record of all was made by a man who reported that he disliked poetry and art. Facility developed as the test proceeded. On no blot did over 40 per cent agree, on some no two persons thought of the same thing. Type of work influenced imagery, *e.g.*, a domestic woman "saw" household objects. Dearborn declares that the test "represents accurately the mental functions upon which wit and mental liveliness depend".

Another article (26) by the same author contains suggestions for the use of the blots. Position of the blot should be uniform for all observers. The blots may be used in investigations of the content of consciousness, of memory, and of qualitative aspects of reproductive imagination. Reproductive imagination may be tested "quantitatively by measurements of the relative times required for a presented suggestive blot to bring to mind its obvious likeness".

Kirkpatrick (54) reported the results of testing 500 school children in naming 4 ink blots, using 1 minute for each. Younger children gave more names but were less critical. Older children prefaced their names with "it looks like". Many children named more than one object from a given class, showing that one idea made others more suggestible (*cf.* Andrews, below).

Parsons (69) used 97 boys and girls aged 7 to 7½ as subjects in a test with the Whipple series 1–10. Five cards were presented at each sitting at intervals of 2 weeks. Method was demonstrated by practice cards and unlimited time was allowed for naming. The average N of suggested associations was 35.74 and ranged from 1 to 147, while the average N of different associations per subject was 8.47. The children seemed to be most interested in animals and human beings, since 54.4 per cent of all the associations fell under these headings. Boys were interested to a greater degree in war and landscapes, (the study was conducted during the World War), and girls in domestic animals. Statistically reliable sex differences were obtained.

Abramson (1) contrasted a test of imagination with a test of observation and memory. Memory was tested by recall of visually presented materials and imagination by the Rorschach black ink spots exposed for 10 minutes to each subject. Three hundred school children, aged 8 to 18, participated. He found that girls were more imaginative than boys. Great facility characterized the imagination at 8 years, indicating a stage of confusion and subjectivism, correlated with the beginning of the child's contact with the social and objective worlds. Parts of animals were most frequently named, objects next most frequently, and persons only rarely at this early age. There was a decrease in imagination at 9 and at 10 years, with a marked decrease at 11 years concomitant with an increase in observation. At 12 years a recovery of power for rich and complex imaginings began and continued to 15 years, concomitant with a decrease in observation. After 15 years a

period of decrease in imagination ensued. Wide individual differences in imagery were found.

Loosli-Usteri (60) employed similar test materials. She contrasted the ten- to thirteen-year-old school children of Geneva to those of Zurich and found that the Geneva children were less stereotyped and banal. Twenty-one orphan boys were studied and were found inferior in imagination to normal children living in their own homes. The tests used by this investigator consisted of 10 symmetrical blots, 5 of which were grey-black, 2 red and grey, and 3 multicolored.

Koht (56) used Rybakoff's blots with a 4-minute period of exposure. Over a thousand subjects, aged 9 to 18, participated. Girls gave more responses than boys. Most of the responses were names of animals and persons; parts of persons, animals, and things ranked next; qualified descriptions of animals, persons, and objects were next in order. Sex differences were less striking than the similarities; girls gave more vague and detailed explanations and saw movement more often than did the boys.

Feingold (35) studied the influence of suggestion on ink-blot responses. The 5 adult subjects were given 1 minute in which to write descriptions for each of 5 ink blots. Post cards were then observed for 45 sec., and 15 sec. was then devoted to reverie on the contents of the post cards. This was followed by a 1-minute trial with the blots. The following results emerged: a decrease of 22.9 per cent in descriptive terms resulted from the suggestion (post cards); an average of 2 ideas per judgment was obtained in the non-suggested series as contrasted to only 1.7 in the suggested series; more failures to identify blots occurred in the suggestion series; at least 25 per cent of the responses in the suggestion series were carry-overs from the post cards. Feingold suggests, on the basis of his findings, that rural children may be more imaginative than urban children, since their surroundings are not so particularized, that is, open spaces stimulate the imagination like the blurred outlines of ink blots.

White (98) studied suggestibility in the Whipple ink-blot test, using preschool children as subjects. In one group of subjects, free naming was followed by names suggested by the experimenter. In another group, the order of procedure was reversed. In free naming, animals (43 per cent) and people (30 per cent) appeared most frequently. White found correlation of —.57 between receptivity to suggestion and repetition of the suggestion at the second sitting.

Ransohoff (76) also used preschool children as subjects. Whipple blots and meaningless pictures from periodical ads were used as stimuli. Highest imagination scores were assigned for consistent naming of the same stimulus; thus measured, imagination increased with maturity. At this early level, the subjects were frequently more interested in manipulating the cards than in naming them. Ransohoff reports positive correlation between imagination scores and I.Q. and age.

Lundholm (62) devised a blot of hazy outline and with scattered abstract lines for use in studying 50 normal and 35 insane subjects. Women were found to be more talkative but men reported more significant images, that is, men used more verbs, nouns and adjectives. Manics reported more significant images than did normals; retarded manic-depressives used fewer words than normals, while the non-retarded used many insignificant words. No coöperation could be elicited from psychopathic and schizophrenic patients.

Other Approaches. Sharp (78) used ink blots as a test of passive imagination. Association in response to abstract terms and number forms was also investigated (*cf.* Stetson) as a function of the passive imagination. Constructive imagination was tested by explanations of a mechanical puzzle after 5 minutes of manipulation, by the construction of sentences from 3 given words, by the development of themes on imaginative and prosaic topics (capture of a fortress *vs.* delays of justice) and by choice of theme topics.

Hargreaves (41) also used ink blots as part of an extensive battery of imagination tests in an attempt to isolate the group and specific factors comprising imagination. Fluency (number of ideas) and originality (number of different ideas) were scored separately. Boys and girls of average age 12.8 years were the subjects. Separate tests of speed of writing and perseveration were made. Opposites, analogies, dissected sentences, concomitant categories, language completion, and filling in stories and pictures constituted the determinate or intelligence tests; the average reliability coefficient for these tests was .46. Completion of pictures so drawn as to make the missing object indeterminate, completing unfinished pictures (in writing), ink blots, indeterminate language completion, completion of stories on the basis of first sentences, and number of words written in 3 minutes were used as tests of imagination; here the average reliability coefficient was .62. Three tests of memory, 3 of writing speed, and 6 tests of perseveration completed the battery.

Hargreaves concludes that tests of fluency of imagination have

a high degree of correlation with *g* but also have an *s* of wide range. A fluency factor probably exists comprising speed plus another factor, but not perseveration. Speed, the main factor in fluency, and the other factor (not memory) are conative in nature, chiefly associative and related to the absence of inhibition. Tests of originality of imagination have a common factor unrelated to *g*, speed, and association by similarity, but related to memory and the fluency group factor. Hargreaves notes that there is some justification for the "faculty" theory of imagination, in that a general fluency factor seems to exist.

Town's (92) study of five- and six-year-old children included the following imagination tests: Heilbronner's unfinished picture in which increasing degrees of completeness are provided (*cf.* Dearborn); sentences containing 2 different words; arrangement of a picture story (these latter tests were unsuccessful at this age); and Healy formboards A and B.

Andrews (5) found that preschool children tend to perseverate in responses to ink blots. Andrews devised a tachistoscope with one-second exposure designed as a window of a house. Parts of objects, lines and dots, and parts of animals were shown to the subjects, and each was asked "What do you see?" Complete objects, Andrews found, stimulated reproductive responses only and were therefore eliminated. The children's responses were scored for rarity (high for lesser frequency) and complexity (high for more complex); the correlation between the two types of scores was .87. Over 100 subjects aged 2 to 6 were given the test, which was found to be reliable. Some findings were: failures to respond decreased from age 2 to 4 and then increased for a half year period and declined again; responses indicating transformations increased up to three years and then declined; reproduction of the stimulus increased up to age 3.3; analogy increased up to age 5 and then decreased. Personification and more complex forms of response were most frequent at ages 3.6 to 4.0. The correlation between M.A. and complexity score was —.20; between complexity score and C.A., .35; and between complexity score and I.Q., .10. Andrews concludes that "intelligence and fantastic imagination are unrelated". Girls reached a peak one year earlier than did boys; boys were less variable; boys' scores declined at a faster rate from the high point than did the girls' scores. Many animals were named in response to the stimuli. The use of the word "like" in describing the stimulus increased up to 5 years (*cf.* Kirkpatrick, above).

Henseling (44) found that school children interpreted irregular geometric forms as representations of objects. Simpson (81) defined creative ability as breaking away from usual thought sequences and assumed that the frequency of spontaneity and the initiation of deviation (unless psychotic) indicated creativity. He used as a test dots in a square on a large sheet of paper, 5 squares on each of 10 sheets. Subjects were required to draw designs by adding 2 more dots and any lines they desired. Drawings were numbered in order of performance and notations were made as to whether the design was thought out or imagined by chance. One point was scored by a change in design. An artist scored 25.6 figures and 22.8 changes of design; 4 Harvard students averaged fewer figures in a given time than did public school children but had more creative changes. After 4 practice periods the average score of the subjects was raised only .5.

Teague (89) attempted to find whether or not imagination was more active when records of music widely advertised as arousing imagination were played and whether records of "imaginative" music would be more effective than other kinds of music. Imagination was tested by Masselon's sentence building with 3 words in a fixed time interval, and by word building. Moods were recorded on a chart similar to that used when the "scientific" standardization of the effects of the phonograph records was made. Two hundred and thirty-four college students participated, divided into 2 groups; 1 group listened to music and then did tests, the other cancelled digits before the tests. Teague concluded that the imaginative series of records were no more stimulating than miscellaneous selections, that only 1 in 4 persons was stimulated imaginatively by music, that 27 per cent were inhibited by music, and that the effects were ambiguous in about half the cases.

Winch (99) investigated the influence of knowledge on vigor and spontaneity of imagination, and the relation between memory and imagination, the latter conceived as the equivalent of invention or productivity regardless of type of imagery used. Imagination was tested by building a story around certain words, and retention of prose material read for 5 minutes comprised the test of memory. Number of separate items constituted the score in each case. Twenty-eight boys of ave. C.A. 13.4 were given 5 imagination and 3 memory tests on alternate sittings over a period of 37 days. Four practice periods in memory were given the trained group; the untrained group used algebra. Posting marks stimulated performance. A

second series of similar experiments was performed with 55 girls of ave. C.A. 12 yrs. 11 mos. as subjects. The practiced group was trained to the point of fatigue in retention. Winch concluded that substance memory and imagination were correlated, and more closely in proficient than in inferior subjects. Transfer of substance memory material did not account for the improvement in invention. Excessive training in substance memory influenced invention adversely; the bad effects of excessive training in memory on imagination are temporary, but the practice effects are permanently beneficial for memory.

Slosson and Downey (**82**) reported the use of "personal" advertisements as source material in plot writing. The following types of imagination were evident from the stories written: the inert, or literal kind that sees nothing in the situation; the conventionalized type; the melodramatic or journalistic type; the generalizing or conceptual, in which the personality is pigeonholed and the individual is lost; the particularizing, reminiscential, creative or dramatic imagination; lastly, the ingenious or inventive imagination. Hints for creative writing were offered: acquire the plot-making set, inhibit inhibition, cultivate the emotions, discover stimulating settings (soft music, etc.) for yourself, experiment in exchanging and discussing plots with others. "Imagination", as defined by these writers, "means very simply that the whole mind is active in a certain way, namely, in the breaking up of old experiences and the using of them in a novel fashion"; the novelist, therefore, needs the power of acquisition and the power of construction; "a plot is a problem". Other suggested exercises in imagination for potential writers were: reading into headlines, eavesdropping on conversations, reading "heart trouble" columns, supplying third lines in syllogistic paragraphs and judging titles and phrases for potential dramatic use.

Partridge (**70**) reported school children's description of an imaginary animal. A total of 148 boys and 182 girls aged 6 to 16 years were subjects. Using a phrase or concept as the unit, girls scored 5.66 units per description, boys 5.58. The younger children described more impossible animals (*cf.* Kirkpatrick, p. 14), usually fierce and large animals. Half of the children reported "seeing things" before falling asleep.

Brittain (**12**) used 19 boys and 21 girls of ages 18 to 30. They were required to write answers to questions on interests and preferences, favorite books, stories, daydreams, poems, and imaginary companions. Tests of memory and imagery type were admin-

istered; imagination was tested by compositions, one set written on a series of stories the subjects of which were chosen by the pupils, and the other on a series of stories suggested by pictures. Favorite subjects were mathematics and geography; many of the pupils studied had written poetry and day dreamed. Seasonal differences in imagination appeared and various external conditions were described as stimulating imagination. Fairy stories and fiction composed much of their early reading. Girls more often reported emotional stories as favorites, boys action stories and humor; boys had fewer interests than girls. Girls wrote longer stories, especially long ones for the sorrowful pictures shown, and showed better memory; boys' stories had little moral content; girls showed greater appreciation of emotions and morals in story writing; boys attained more unity in stories and used the first person more often. All but 2 or 3 of the subjects had gifted imaginations, according to the author. Emotions and the type of life led seemed linked to imagination.

Colvin and Meyer (22) required children in the four lower grades to write compositions on the following topics: funny story, fairy story, good joke, how flowers are colored, the story of a poor boy or girl, what I see on the way to school. Four high school classes wrote themes on a voyage in an air ship in 2000 A.D., how the flowers got their colors, what I see with my eyes shut, my first visit to the theatre, adventures of a school desk, displays in the shop windows, a laughable story, a poor family, a fairy story, a comical character, the woods in autumn, jokes I have played. No comments or corrections were allowed; 3,000 returns were sent in. The form of images and types of imagination were classified as heroic, dramatic, religious, melancholic, etc. Scientific and melancholic imagination appeared at adolescence, and increased during this period. Heroic imagination was at its height in the secondary school, mythological was at its peak in the grades, and religious imagination in the fifth grade. An apparent decline in imagination seemed to take place as age increased (*cf.* Kirkpatrick, and Abramson); education tended to crush imagination; at puberty images of the old and especially of the lower self dropped out with the dissociation of the neurones(!); little humor was apparent in the children's compositions, possibly because of the system of education; there was slight rise in emotional feeling at puberty, not at all in proportion to the tremendous increase in the emotional life at this time; the school was indicted as mechanical, repressive, and formalized.

Libby (58) investigated the imagination of adolescents. A draw-

ing depicting a man riding off as a weeping woman stands at a gate was presented to fourth year high school students and to ten- to fourteen-year-old children for theme writing. High school students made subjective interpretations and recognized the love element; grade school pupils were " objective ". When feeling was involved, as in this instance, it was possible to differentiate prosaic from imaginative thinking. Adolescence, according to Libby, is a time of rich emotional life, hence there is more imagination in the compositions of adolescents.

Chalmers (18) used a questionnaire on childhood interests in play and reading, concepts of number and time, and the extent of visualization in thinking. Adult subjects, 121 men and 161 women, took part, all university students or teachers. A few women reported that they did not like dolls as children; dolls were abandoned by many to indulge in daydreams or because of a feeling of shame. Women could revive the feelings concerned with dolls and the emotions quite readily; doll play continued longer than play of any other kind. Half of those reporting having had dolls saved dolls for their associative value. Adults did not highly evaluate imagination in reading, that is, information was stressed. To the questions whether a sex could be assigned to certain numbers and whether certain numbers were thought of as stronger than others, 118 answered in the affirmative.

Phantasy, Daydreams, Invention. Sherman (79) describes his studies of daydreams in the preschool child. Some children should be encouraged to daydream for the sake of stimulating creative imagination, since " ability to combine imagination with reality is probably the cause of the productivity " of the gifted. Dictaphones were used to secure records of spoken phantasy, which is common at the preschool age but is inhibited by adults in later life, and inhibited also at early ages by the presence of adults. Phantasy was found to be used for wish fulfillment, and to occur more often in new and puzzling situations and also at bedtime. Presence of another person inhibits the phantasy. Records of casual and systematic phantasy were obtained. Dramatic and prolonged phantasy often signified that the child had serious personality difficulties which might lead to chronic habits of introversion. Less intelligent children had phantasies more rarely than the more intelligent ones. Phantasy gives the " creative stamp to intelligence ", according to Sherman.

Green (38) analyzed the daydream as a phenomenon of development with definite stages or phases. He stressed its value as an

instrument for finding out about children, since the child does not know its meaning and cannot transform it to suit the adult.

Varendonck's (94) study described his daydreams, written into a diary as they occurred. Phantasies, he found, tended to break into consciousness or action, whether the meaning was overt or symbolic; one may or may not be aware of this tendency—in slips of the tongue one is not. The daydream often functioned as a compensation for harsh reality. Phantasy may assist the conscious self in creative tasks. Often the phantasy may be an escape from the stringent censorship of consciousness. "Our daydreams may be so absurd that one is tempted to say that a certain amount of madness is normal to phantasies, and that lying seems a natural product of the conflict of wishes."

Partridge (70) reported the results of a questionnaire on reverie, fancy, imagination, daydreaming, absorption, castle building, etc., using 337 normal school students aged 16 to 22 years. The concomitants of reverie were staring eyes, blank expression, a motionless body, general muscular relaxation, and anesthesia. Solitude and fatigue, repression and music often induced the state. Dreams of fame and wealth were common. Noises and voices caused awakening in many cases. R[illegible]e is the play period of the intellect, according to Partridge, and in reverie the genius conceives its works; most studies, he found, show a rise in reverie at or after 10 years. Biography, drawing, and poetry were recommended to stimulate reverie.

G. S. Hall (40) found that cloud fancies are often of delusional intensity causing, at adolescence, especially, a "yearning for unearthly beauty". Girls suffered "nephilopsychoses" more often than boys. Cloud fancies, according to Hall, are phylogenetic in origin. Clouds probably, at one time, were symbols of divinity; the tendency to see things in clouds indicates a mythopœic "faculty".

Smith (83) investigated the daydreams of 980 school children aged 7 to 16, 469 young people, 17 to 25, 23 adults and 3 old people by a written questionnaire. Psychic deafness and muscular relaxation were characteristic of daydreams; solitude, soft music and monotonous sounds, as in hypnosis, induced them in many cases. Dreams of wealth were common at ages 9 to 10; having autos at 10; from 10 to 15, boys dreamed of athletics a great deal; few fame dreams were found before adolescence; the continued story type of daydreams predominated in adolescence. Love and marriage did not appear in daydreams until after 17 years of age. Dreams of having a

job were frequent among poor children even as early as 9 or 10 years. The imagery aroused sometimes seemed involuntary. Most children reported that they liked to daydream; at later ages some subjects declared that daydreaming was harmful or wrong. Smith concluded that daydreams were characteristic of the child and especially of the adolescent, and that the content was determined by environment. Creative imagination, according to Smith, functions in daydreaming when the facts demanded by its problems have been acquired.

Jersild *et al.* (48) studied 400 school children aged 5 to 12 by the interview method. Daydreams, as reported by the children, were found to bear more resemblance to the wishes reported by the children than to their expressed fears. Of the reported reveries, 32.5 per cent centered about thoughts of diversion and play, 19.0 per cent about prestige, 12.8 per cent about having food, money, etc. Children expressed more philanthropic ideas in their wishes than they reported in their daydreams. Older children had more dreams of heroism, and younger more of play; younger children reported fewer daydreams. Children of relatively high intelligence reported more daydreams than did those of lower intelligence. Children from an unfavored social group (public school) had more unpleasant and morbid daydreams than did children from relatively superior homes (private schools). Of the 400 children, 143 reported on phenomena that resembled the "imaginary companion"; 58.8 per cent of the imaginary companions were imaginary sibs or babies. A reliable difference in intelligence in favor of the companion group was found between the group reporting companions and the group reporting no companions. Girls more frequently described companions of the opposite sex than did boys.

Hurlock and Burstein (46) conducted a questionnaire study of 701 high school students and college graduates and found that 31 per cent of the girls and 23 per cent of the boys reported imaginary companions. Size of family and early surroundings had no apparent influence on the presence or absence of imaginary companions. Boys tended to have the companions at a later age than did girls. The average age of appearance of the companion was between 7 and 9. The companionship of real children was most frequently given as the reason for abandoning the imaginary playmate.

Nice (66) observed imaginary companions, fantastic animals, and continued story phantasies in her daughter at the age of 3½ years. Nice found that imagination was stimulated by an unexciting life, that imagination was not correlated with the child's literary experi-

ences, but that imaginative stories tended to inhibit imagination. Absorption in real life and ennui with imaginings seemed to attend the disappearance of fantastic moods. Katz (51) observed her son's invention of tools. She reports at length on the child's eidetic imagery and phantasy.

Vaschide (95) observed that, up to the age of 4, creative activity was found in children with a poor fund of experience and poor memory. Imaginings, he found, had associative connection but also depended on chance elements. These young children had difficulty in distinguishing the real from the unreal. Language followed rather than preceded imagination in development. Creative imagination seemed partially due to absence of correct perception, partially to errors of sense and confusions in imagery, partially to chance synthesis of hallucinations.

Dell (29) found that his child, aged 3½ years, carried over dream symbolism into waking life. Webber's (96) observations on a young child stress the fact that valid observations of creative imagination in children must be based on intimate acquaintance with the child. He cites an apparently fantastic story which was nothing more than a synthesis of the direct and vicarious experiences of the child, which, in this instance, were known to the observer.

III. Theoretical Discussions

Burnham (14) cites Kant's dictum that creative imagination is non-quantitative but depends on measurable sensations. Spearman (84) stresses the realistic and analyzable nature of creativity; cognitive rather than affective and volitional aspects are considered of most importance. Burnham considers that all persons, with the exception of the extremely feebleminded, possess imagination; the range is continuous from the prosaic to the idealistic.

Downey (32) stresses analytic features in her summary of theories of art and relates the appreciation of art to projection, vividness of imagery, and empathy. Dugas (33) considers that imagery is dependent on sensation and that therefore faults in imagery result from faults in sense. Imagination may depend on an objective (science) or a subjective (art) criterion. A summary of experience guided by interest may be termed reproductive imagination; mere redintegration, however, is not creative.

Imagination, according to Squires (85), comprises "responding to the physically absent as though present". Imagination produces nothing beyond sensory data, *e.g.*, the congenitally blind do not see

in their dreams. Clapp (20) states that imagination consists of the representation of images and objects and the conception of combinations not given in reality. The forming of images is only one aspect of creative imagination, according to Libby (58). Keyser (52) criticizes the use of the term image; imaginative products are distinct from replicas of percepts. Markino (63) explains that the quality of the imagination depends on memory. Hibben (45) stresses the logical nature of the dialectic imagination and its relation to artistic powers. Davies (24) finds that the imagination is predominantly cognitive in nature.

Henseling (44) contrasts phantasy and reality thinking; phantasy disavows the rules of reality. Elsenhaus (34) considers that phantasy explains the creative force responsible for the original discoveries of science and art. Creative power is based on fullness and richness of knowledge; thus, although the image may not be used, it is always in preparation for use. Fischer (36) considers that phantasy may best be studied by introspection and the analysis of cultural material such as play and drawing. Bolton (9) considers that make-believe is the trial and error process of ideation. Emotions are the mainsprings of imaginative behavior: "In the case of the scientific man doing inventing, one individual is thinking a succession of thoughts with variations. When a thought has arisen which, when carried into action, satisfies the want that has unsettled the thinker, the process comes to an end."

IV. Imagination in Education

Johnson (49) finds that children dramatize their most familiar experiences; excursions are therefore useful in promoting dramatic play, which "means first and last, with young and old, reproducing a personal experience". Imagination means transcending the literal, according to Mitchell (65). Phantasy is useful for those who can distinguish the real from the unreal; young children need no escape into phantasy, therefore exploration should be given free scope in their play at early ages, and only realistic literature should be provided at early levels.

Blatz (8) finds that undesirable traits, such as lying, may generate from the habit of imaginative embroidering. Alexander (3) thinks that lies come from the child's desire to find comfort in difficult situations which he is not yet willing to endure. Goschen (37) emphasizes the fact that good and bad uses may be made of imagination, according to training. Brill and Youtz (11) declare that

parents, under ordinary circumstances, should not be alarmed by lying, daydreams, or imaginary companions, which are common forms of imaginative expression in the young child, but should endeavor to teach the child the distinction between real and unreal. Sherman (79), Nice (66), and Andrews (5) stress similar principles.

Cadman (15) urges parents to participate in their children's imaginings but to guide them back to reality when necessary. Church (19) considers that children's phantasies may be a valuable outlet for their parents.

Kirkpatrick (55) discusses general aspects of imagination in education. He points out that, like all intellectual processes, imagination depends on sense material. Creative imagination, however, is regulated by the emotions, desires, and purposes. He differentiates the genetic development of imagination as follows: "The period from 3 to 6 is predominantly the time in which free play of the imagination is contrasted with fixed sensory experiences of the immediate environment. From 6 to 12 the imagination is occupied with constructing the distant world of reality and perhaps reveling in a fairyland where wishes and fancy play a large part. From 12 to maturity is the period of adventure, romance and idealism in which the real world is the theater of the imagination but the desirable is selected and action is speeded up and intensified." He cites many practical applications to education of the psychology of the imagination.

Dewey (31) discusses the problem of imagination in pictorial art. Idea and technique both present problems of imagery; technique is not a purely mental process and idea a spiritual one. Objects frequently aid the construction of the image in drawing.

Hale (39) advocates stress on creative rather than on imitative art; formal standards of drawing do not measure creativity. Hasbrouck (42) considers that art should not be used for its end results but rather as a medium of expression. Children should learn and should be taught respect for tools, appreciation of the value of touch, and joy in the choice of color and form. Cane (16) points out that drawing is as natural a channel of subjective experience as is speaking; educators should not check or criticize children in the exercise of the creative impulses. The teacher should understand the child and should be able to teach care of materials, and strength and control of movements. Mathias (64) stresses the fact that children use drawing as an emotional outlet rather than as an expression of meanings; for example, the child draws houses small because they are unimportant in his sphere. Mathias urges the use of materials in

the curriculum as means of providing physical activity, mental development, social habits, and lasting satisfactions to the child.

Cane (16) found that three-year-olds were more interested in paints than in other materials. She stresses the emotional outlets found by many of the children in work with paints. One maladjusted child found, during painting, opportunities for social contacts. Lowell (61) urges more stress on expression and less on practical subjects; she considers that literature and the humanities cultivate the imagination. Otto (68) points out that truth is well digested fact plus imagination; teachers with imagination are needed to give wider meanings to the simple facts of the curriculum, especially in the social sciences. Pearson (71) urges the cultivation of the art of contemplation or reverie as an antidote to the age of indirection, hurry, and noise. Copper (23) discusses creative imagination as the source of cultural advance, an enricher of life, and the natural outlet of the tendency to express oneself constructively. Brown (13) thinks that education should provide outlets for creativity, since society does not.

Presler (74) describes a creative program. Expression springs from a background of imagery, information, and feeling, and is the overflow of rich experiences. Seybold (77) considers the class project one of the most effective avenues for creative release; club activities are also recommended. Shipley (80) thinks that the will to act, to know, and to control should be developed before the will to imagine will be aroused. Swartz (87) considers that good reasoning is the basis of imagination; therefore provision for rich percepts, use of problem material, and training in powers of judgment will insure training of the imagination. Tuttle (93) accuses educators of giving too little attention to imagination, especially in character education: "Vicarious experience permits the full operation of the law of effect in setting up revulsion at evil, without wounding the character in its discovery." Bailey (6) emphasizes the need for the constructive use of leisure in all types of artistic pursuits as a means of character training, since avocations are of great importance in molding the personality.

Adams (2) states that regulation of the imagination is the most important objective of education and that this is best accomplished by manipulating factual censorship of phantasies.

Jewell (50) describes her work with high school freshmen who had failed in English. The geography and English teachers worked coöperatively to arouse "dormant" imagery about distant lands. At

the end of several weeks of such training the pupils were able to cope with the rich imagery of the Homeric poems.

Kilpatrick (53) discusses the diversity of opinion and confusion in modern education concerning creative expression: "Whether we call it thinking or learning or creating it is the same active constructive grappling with impending fortune to manage it to our own ends." Creativity is not an all or none phenomenon, but is a continuous scale of events which plays a part in the life of everyone, even in apparent imitations. Art is an attempt to meet life fully and to create the best possible answer to its demands.

A symposium (88) reveals varying points of view on creative expression in the school; children must learn to be free under conditions which prevail in the world; children's interests should not be the only guide in curricula, but the teacher should play a part too; uncontrolled creative expression is a poor method of coping with the conflict of new values and old ideals of education, etc.

Dengler (30) advocates a curriculum which strikes a happy medium between excessive freedom and excessive formalism; children can be taught to enjoy hard work and to do it creatively.

V. Summary

Conceptions of the nature of imagination vary from definition as the simple reproduction and reconstruction of sense material by the use of imagery to views of creativity as a mysterious force or instinct which transcends description. Cognitive and quantitative aspects on the one hand are contrasted to affective and qualitative theories on the other. In education formal training programs, as opposed to creative expression programs, illustrate this difference. Research has not been sufficiently varied or extensive to determine conclusively the validity of either type of approach in nurturing the imagination. Theory, practices, and experimental data on imagination are notably uncoördinated.

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A BIBLIOGRAPHY OF ARTICLES IN PSYCHOLOGY: NOSOTROS. VOLUMES I–LXXVI

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Nosotros is a monthly review of Argentina. With Roberto Fernando Giusti and Alfredo Antonio Bianchi as editors, its publication began in Buenos Aires in August, 1907, and still continues. In addition to the typical creative prose and poetical works usually found in a literary review, it contains hundreds of scholarly articles in such fields as anthropology, art, education, economics, history, literary criticism, music, philosophy, philology, sociology, political science, and religion. At present there is no complete index to this mass of valuable material.

The purpose of the accompanying bibliography is to make available all the articles of *Nosotros* in the field of psychology, during the first 25 years of publication. The first 76 volumes are covered, and the study is brought down to October, 1932.

In the notations accompanying the items, it has been our purpose to indicate the contents of each article only to such an extent as to make possible immediate decision upon its value for any specific study. The notations, therefore, are in no sense to be considered as summaries. If *Nosotros* should not be available in a local library, it is hoped that the notations will be useful in determining the advisability of inter-library loan applications.

1. Agote, Luis, *Nerón. Los suyos y su época.* **9**: 62–64, November, 1912. Reviewed by Alvaro Melián Lafinur.
   A book based on the belief that Nero belonged in the domain of historical alienism.
2. *Anales de la facultad de derecho y ciencias sociales.* **33**: 279, October, 1919. Reviewed.
3. *Anales de psicología.* **22**: 99–100, April, 1916. Reviewed.
   The table of contents of Volume 3 of the *Anales* is given.

4. Areco, Horacio P., *Enrique Ferri y el positivismo penal.* **3**: 120–121, August-September, 1908. Reviewed by Roberto Fernando Giusti.
5. Areco, Horacio P., *Psicología legal.* **9**: 450–452, February, 1913. Reviewed by Coriolano Alberini.

   A series of lectures by Areco.
6. Areco, Horacio P., *Los temperamentos humanos.* **12**: 94–98, October, 1913. Reviewed by Enrique Mouchet.

   Temperaments are classified as being either positive or negative, and the differences between the normal, the mediocre, and the man of genius are discussed.
7. Asnaourow, Félix, *Progresos de la psicología.* **40**: 55–59, January, 1922.

   In this article are discussed such topics as the influence of incidents during childhood and puberty on the life of man, the effect of the subconscious, and psychoanalysis. Different studies of each are mentioned. The conclusion is that the end of individual psychology consists in discovering man's fundamental complexes.
8. Bermann, Gregorio, *El genio.* **36**: 230–235, October, 1920.

   The conception of genius as given in the book by Alberto Palcos. The characteristics of genius are discussed, and the social, economic, intellectual, and spiritual factors that are favorable to it.
9. Bermann, Gregorio, *Psicología de la apetencia tóxica.* **53**: 338–359, July, 1926.

   Noting a desire for drugs as one of the characteristics of contemporary life, the author analyzes the cause of this desire and describes the physical and psychological effects of different drugs.
10. Brentano, Francisco, *Psicología.* **59**: 117, January, 1928. Reviewed by Francisco Romero.
11. Brughetti, Faustino, *El subconciente.* **67**: 103–106, January, 1930.
12. Corti, Alfonso, *Sobre la "Psicología musicale" de Mario Pilo.* **7**: 35–42, January, 1912.

    A discussion of sensory and sentimental music.
13. Delgado, Honorio, *Sigmund Freud.* **58**: 337–338, November-December, 1927. Reviewed by A. P.

    This work is noted as being a physical, mental, and ethical portrayal of Freud, taking into account his works and the critical literature about him.
14. Doll, Ramón, *Enrique Ferri, penalista y politico.* **64**: 107–111, April, 1929.

    In this note on the death of Ferri, the author praises his investigations in penology but condemns his work in politics.
15. Ducceschi, V., *La criminología moderna.* **12**: 90–93, October, 1913. Reviewed by Enrique Mouchet.

    A list of the eight chapter headings in this work is included in the review.
16. Etchart, Carlos Rodríguez, *La ilusión.* **11**: 299–304, September, 1913. Reviewed by Enrique Mouchet.

    A definition of both illusion and hallucination, followed by a study of the various kinds of illusions.

17. ETCHART, CARLOS RODRÍGUEZ, *Psicología energética.* **11**: 200–204, August, 1913. Reviewed by Enrique Mouchet.

    The review lists the chapter headings in this work.

18. FERNÁNDEZ, HELVIO, *Ingenieros psiquíatra.* **51** bis : 563–571, December, 1925. Illustrated.

    A list of the psychological studies of Ingenieros with an evaluation of the man as a psychologist.

19. FREUD, SIGMUND, *El porvenir de las religiones.* **71**:210–211, February, 1931. Reviewed by F. R.

    This volume of essays is noted as containing studies on Freud, Spengler, and Keyserling, on the significance of religion, on the technique of psychoanalysis and on narcissism.

20. GIUSTI, ROBERTO FERNANDO, *La polémica sobre Freud.* **47**: 396–399, July, 1924.

    Note on "the last number" of *Le Disque Vert* which has been entirely devoted to studies on Freud and on psychoanalysis and upon an article on Freud by Marcel Ball in the *Mercure de France* of July 10. The author of this article then summarizes the conclusions of these studies.

21. GÓMEZ, EUSEBIO, *La mala vida en Buenos Aires.* **3**: 120–121, August-September, 1908. Reviewed by Roberto Fernando Giusti.

22. INGENIEROS, JOSÉ, *Principios de psicología.* **24**: 401–405, December, 1916. Reviewed by Alberto Palcos.

23. INGENIEROS, JOSÉ, *La psicología social de Hispano-América.* **29**: 397–398, July, 1918.

    A discussion of Carlos Octavio Bunge's *Nuestra América* and of its attempt to find an ethnic basis for the psychological character of Hispanic America and to portray caudillism.

24. INGENIEROS, JOSÉ, *La psicopatología en el arte.* **34**: 145–162, February, 1920.

    The theme of this lecture is that art has created great psychopathic types whose analysis can be of use to the modern student of mental pathology. The author discusses such characters as Lear, Othello, Macbeth, and Hedda Gabler and includes bibliographical notes.

25. INGENIEROS, JOSÉ, *Sobre el amor.* **2**: 384–389, July, 1908.

    A study of the relationship of love to timidity and to service and of its various forms. Love is classified as a useful but chronic sickness for which matrimony may prove the best antidote. The study concludes with mention of famous lovers of the past.

26. IPIÑA, LUIS, *Pequeño comentario de ideas sobre la pasión.* **6**: 425–436, December, 1911.

    A study of such aspects of passion as egotism, avarice, sex, modesty, jealousy, etc., followed by lamentations on the subject of woman.

27. JESINGHAUS, CARLOS, *Las bases científicas de la orientación profesional.* **63**: 30–46, January-February, 1929.

    In this application of psychology to pedagogy, the author studies the factors necessarily underlying any successful professional orientation, the advantages and results of such orientation and the courses offered in the Institute of Buenos Aires for the purpose of furnishing aid in this respect.

28. MANDOLINI, HERNÁN A., *Ensayo sobre la psicología del hombre de genio.* **34**: 133–135, January, 1920. Reviewed by Alberto Palcos.

The author concludes that genius is neither degenerate nor infirm, but a happy variation in the species. He also discusses the sex character of genius.

29. MARTÍNEZ PAZ, ENRIQUE, *Carlos Octavio Bunge. Filósofo del derecho.* **29**: 384–396, July, 1918.

A study of Bunge's sociological work. Taking the psychological evolution of the individual as his point of departure, Bunge progresses to the study of the life of society. Psychology, therefore, becomes fundamental in his system and the basis of history, geography, ethics, law, politics, sociology, and education.

30. MERCANTE, VÍCTOR, *La crisis de la pubertad y sus consecuencias pedagógicas.* **30**: 478–481, November, 1918. Reviewed by Alberto Palcos.

The psychological need for the intermediary school.

31. MERCANTE, VÍCTOR, *Significado pedagógico de la vocación.* **27**: 433–442, December, 1917.

The author stresses the advisability of breaking away from the rigid uniformity of present educational practice and of giving proper cognizance to the psychological effects of adolescence and of adapting educational procedure to its needs; he also stresses the practical patriotism of the educator who shall train leaders for the nation.

32. MERCANTE, VÍCTOR, *Teoría de la vocación.* **27**: 302–310, November, 1917.

Ethnic factors in Argentina may well lead to a psychological instability which must be corrected by education.

33. MOLINA Y VEDIA, JULIO, *Sobre el problema de la conciencia.* **18**: 290–293, June, 1915.

An uncomplimentary discussion of *Principios de psicología biológica,* by José Ingenieros.

34. MONTESANO DELCHI, ARTURO, *El problema de la conciencia.* **68**: 231–246, May, 1930.

A study of conscience "in its essence, in its mechanism, and in its development", *i.e.,* the "philosophical-metaphysical, the psychological, and the moral-religious" aspects. The emphasis of this article is on the psychological aspect.

35. MONTESANO DELCHI, ARTURO, *El problema de la conciencia.* **68**: 339–354, June, 1930.

The author discusses the ways in which the exterior world acts upon personality and the "normal and abnormal" manifestations of conscience. Evolution is portrayed as "an uninterrupted chain of successive states of consciousness".

36. MOREY OTERO, SEBASTIÁN, *Elementos de psicología.* **75**: 321, July, 1932. Reviewed by F. R.

This review lists the chapter headings of the work.

37. MOUCHET, ENRIQUE (with ALBERTO PALCOS), *Ingenieros psicólogo.* **51** bis: 572–593, December, 1925.

In this consideration of Ingenieros as a psychologist, the author notes studies on such topics as insanity, hysteria, and crime. He lists other psychological studies as well as the topics treated in the *Principles of*

Psychology, and, finally, defines Ingenieros' attitude toward psychology in its relationship to other sciences.

38. PALACIOS, ALFREDO LORENZO, *La fatiga y sus proyecciones sociales.* **44**: 285–286, June, 1923. Reviewed by Prof. M. L. Patrizi.

39. PALCOS, ALBERTO, *La actividad creadora en la juventud y en la vejez.* **11**: 303–304, September, 1913. Reviewed by Enrique Mouchet.

The author believes that youth excels in creating and age in conserving.

40. PALCOS, ALBERTO (see Enrique Mouchet. Item 37).

41. PALCOS, ALBERTO, *Th. Ribot.* **24**: 423–425, December, 1916.

Note on the death of Ribot and his work in the "new psychology".

42. PALCOS, ALBERTO, *La vida emotiva.* **52**: 436–437, April, 1926. Reviewed by Augusto Bunge.

The first part of this work is a "study of the evolution of the theory of emotions"; the second part is comprised of three essays in which are studied the importance of "emotion in the mystics, in actors, and in orators". In a concluding chapter the author "summarizes . . . the fundamental concepts suggested in the course of the work".

43. PONCE, ANÍBAL NORBERTO, *Psicología infantil.* **71**: 320–322, March, 1931. Reviewed by Arturo Montesano Delchi.

The review notes that this work is a collection of ten lectures on child psychology.

44. QUESADA, ERNESTO, *Ferri conferencista.* **3**: 7–29, August-September, 1908.

Notes on the lecture tour of a specialist in criminal sociology and penal law. The author lists the titles of numerous lectures, bemoans the superficiality of this work of "mere popularization", and describes Ferri's personality.

45. RABINOVICH, MARCOS, *Psicología freudiana.* **67**: 91–102, January, 1930.

An analysis of Freud's *Studies on Hysteria* and of the fundamental principles of his psychology which differentiate it from the traditional conception.

46. RAMÓN Y CAJAL, SANTIAGO, *El renacimiento de la doctrina neuronal.* **2**: 92–93, January-February, 1908. Reviewed by Alfredo Costa Rubert.

47. RAMOS MEJÍA, JOSÉ MARÍA, *Las neurosis de los hombres célebres en la historia argentina.* **59**: 124–126, January, 1928. Reviewed.

The review notes the prologue by Francisco de Veyga as of interest in this edition.

48. RIVAROLA, RODOLFO, *Filosofía, política, historia.* **27**: 117–119, September, 1917. Reviewed by Alberto Palcos.

Two works of Rivarola's are discussed and the second, on *La actualidad política y los estudios de filosofía y letras,* is noted as containing a lecture on "introspection in psychology".

49. ROJAS, NERIO A., *La literatura de los alienados.* **11**: 196–200, August, 1913. Reviewed by Enrique Mouchet.

The first part discusses both normal and abnormal imagination and its expression in language; the second describes the literature of various abnormal types—paralytics, epileptics, etc.; the third contains medical-legal commentaries and an appendix of the author's personal opinions on the subject.

50. ROJAS, NERIO A., *Poetas y locos.* **11**: 245–255, September, 1913.
The emotional element in both poets and the insane, and its effect on literary ability.

51. ROJAS, NERIO A., *Psicología de Sarmiento.* **22**: 306–308, June, 1916. Reviewed by Julio Noé.
A psychological study of a famous Argentine statesman and educator and author.

52. ROMERO, FRANCISCO, *Max Dessoir.* **52**: 277–279, March, 1926.
In this article Dessoir's relation of esthetics to psychology is discussed, and his various psychological works are mentioned.

53. ROMERO BREST, JORGE A., *El elemento ritmo en el cine y en el deporte.* **66**: 352–367, November, 1929.
A definition of rhythm; an account of its mathematical, psychological, physiological, and social factors in music, the cinema, and sport. The article concludes with comment on the esthetic value of sports.

54. SFONDRINI, CARLOS, *Características afectivas del hombre de genio.* **66**: 215–221, November, 1929.
The fundamental characteristic of the man of genius is his superior capacity for feeling and his peculiar sensitiveness.

55. SONDERÉGUER, PEDRO, *Un problema eterno.* **9**: 166–170, December, 1912.
A study of love in its different manifestations in man and woman with the conclusion that every woman presents a problem requiring a different solution. Such phases as coquetry and modesty are also discussed.

56. TABORDA, SAÚL, *Niñez-Juventud.* **75**: 19–30, May, 1932.
The author notes that the apperceptive element is that which distinguishes the man from the child. The child's world is one of activity, of play, and its diverse elements are relatively independent of each other; the interrelationship of those elements creates the man's universe.

57. TERZAGA, ANDRÉS (HIJO), *Las palabras.* **10**: 286–290, May, 1913.
Comment on the power of words to create impressions.

BOOK REVIEWS

Handbook of General Experimental Psychology. Edited by Carl Murchison. Clark University Press, 1934. Pp. xii+1125.

This is a revision of the earlier *Foundations of Experimental Psychology* (1929), a book which has demonstrated its unquestioned value to students of psychology during the five years since its publication. The present edition will be indispensable to all, whether students or teachers, who are seriously interested in current psychological research. Each of its subdivisions, prepared by a specialist, presents its material more effectively than can be found elsewhere within equivalent space. The editor is to be commended for a notable achievement.

The contents of the former *Foundations* have been so subdivided as to form the nucleus of three *Handbooks,* namely, *A Handbook of Child Psychology* (1933), *A Handbook of Social Psychology* (to be published), and the present volume. Such a course was wisely chosen as the alternative to the publication of a several volume edition of the original *Foundations.* In this process the *Handbook* lost eight chapters: three dealing with the individual, in infancy and in school; one with the adult in the community; one with the abnormal individual; one with cultural problems; and two with principles of statistics. In place of these there have been added five chapters as follows: two to the original two on learning; one to the original two on vision; one to the original two on audition; and a new chapter on "Work of the Integrated Organism". Shorter by three chapters, the revision is more than 200 pages longer than the first edition.

Something should be said concerning the change of the title from *Foundations* to *Handbook.* Although the name is of no great consequence, the reviewer distinctly prefers *Foundations.* Implying, as that name would seem to do, the underpinnings of psychology, it is not inappropriate that there should be contributions from biologists, physiologists, and biophysicists to the extent of some 500 of the 1100 pages. Most psychologists have come to look upon their science as "secondary", in the sense that it rests upon or draws heavily from physics, chemistry, zoölogy, and physiology. That a handbook which presumably contains the working materials of our science should draw so heavily from abroad suggests a dearth of psychological substance

which is scarcely justified by the facts. The danger is that emphasis upon foundation material may crowd out of the *Handbook* important sections of superstructure. Thus reaction time, a field in which quantitative measurements have been made since the first psychological laboratory was established, is not represented except by casual references here and there. Perception, likewise, has long been and still is a field of active research. A vertical rather than horizontal division of subject matter would scarcely justify exclusion of these two fields from the *Handbook,* although it might account for the absence of a treatment of reasoning and the so-called higher mental processes generally.

Of the five new authors added in the revision, two are physiologists. The reviewer does not mean to belittle the value of "non-psychological" contributions. On the contrary, he considers these the more important since they make much needed material accessible to the psychologist. He would prefer to see the two treatments kept fairly separate if only in order that each may be adequately covered. For instance, there might be added to a *Foundations* a chapter on the chemistry of behavior, the physics of behavior, and possibly one on the physiology of movement. Gaps in the content of the *Handbook* have already been noted.

The *Handbook* is a real revision over and above the addition and subtraction of whole chapters. Naturally, the extent of the changes varies from topic to topic, from no change in one case to a complete rewriting in another. Some indication of the freshness of the content may be obtained from a survey of the references. Of the 2,500 references in the volume, over 500, or about one-fifth, have been published since 1929 when the *Foundations* came from the press. In the revised chapters one out of every six references is dated 1929 or later, while in the new chapters, one out of every three is dated 1929 or later. Omitting three of the revised chapters in which the fewest new reference were added, the ratio becomes one out of five instead of one out of six.

As the page layout is the same in the original and revised editions, one can readily note changes in the number of pages devoted to the various chapters. The added pages in the revised chapters vary from none to 68, with 9 having added 10 or less, and 4 having added 50 or more.

There are few changes in style in the book as a whole. One notable change is in the citation of references. Whereas the original volume referred by number to the bibliography, the revision refers

by year of publication with small letters a, b, c to distinguish publications within a single year. This conforms to more common usage, and recognizes the pertinence of the date in evaluating the report of research. An attempt has been made also at a systematic classification of the various contributions by dividing them into two groups, adjustive processes and receptive processes. It would have been somewhat neater, perhaps, if there could have been a threefold division into receptive, adjustive, and reactive. Still, such a classification might have been forced, for the reviewer at least would experience some difficulty in allocating chapters to these three classes. One notes a better adjustment of size of illustration to the page, and a more effective positioning of illustrations in the revision.

In a joint project of this sort, one looks with a critical eye for overlapping of fields, duplication of references, and other evidences of waste. They seem to be negligible in this case, a tribute indeed to the planning ability of the editor and the coöperative spirit of the contributors in keeping rigidly within their assignments. A few sample references followed through showed Adrian, *Basis of Sensation* listed five times, Cannon, *Bodily Changes* listed four times, and Creed, Denny-Brown, etc., *Reflex Activity* listed three times. This is no more repetition than one might expect to find in a book by one author where there were chapter bibliographies. An inviting spot for overlapping occurs in the case of the maturation process in relation to learning. A special chapter is devoted to this topic and a reading of the other three chapters on learning shows the topic carefully shunned, although with some evidence that in so doing a modicum of restraint had to be exercised. One looks also for signs of prejudice, bias, and pet theories of the individual contributors in a composite work of this sort, which if present might be inappropriate for a handbook. Little criticism can be raised in this respect, however. There are cases where the initiated can see theories getting somewhat out of hand, but rarely will the reader be disturbed by such favoritism. The revision is a distinct improvement over the original in this respect.

The space allotted to this review of necessity will be devoted to a consideration of the new sections of the book and to those revised sections where there has been some radical change. (A detailed review of the original edition will be found in the PSYCHOLOGICAL BULLETIN, 1931, **28**, 145ff.)

The most radical revision is that given to the original chapter on " Space and the Non-Auditory Labyrinth ", where author, title, organ-

ization, and content are all changed. Holsopple had given a rather discursive treatment of the subject under the above title, justifying his procedure by the statement that he attempted "to provide a basis for understanding the problems of the vestibule rather than to compile a handbook or encyclopedia of information". He did not cite a single reference in the text, although he did provide a bibliography of 16 references for further reading. Dusser de Barenne, on the contrary, under the title "The Labyrinthine and Postural Mechanisms" offers a genuine handbook of information on the subject, citing 216 references in the text. The research material, almost as confusing in its contradictions as that on the skin senses, is well organized under the following heads: methods of research; the labyrinthine reflexes, including acceleratory and position reflexes; and the results of labyrinthectomy. The chapter concludes with a section on animal posture and its central mechanisms. Less than 10 of all the references cited are the work of psychologists, and of these 6 belong to Dodge. This is, indeed, a field where psychologists have been relatively inactive, although, as Holsopple pointed out, it is rich in psychological problems.

A rather radical revision occurs in the chapter on "The Pressure, Pain and Temperature Senses", by J. P. Nafe. There is a change in title, point of view, and content, with an increase of 50 pages in space devoted to the subject. The task of reporting the results of research in this field is a stupendous and exasperating one. Nafe in the original edition chose to present his own quantitative theory first and treat the data as they bore upon this theory. The title "Feeling Sense" indicates this preference. The revision, however, offers a thorough, balanced presentation of the evidence from research, with the author's quantitative theory modestly offered at the conclusion of the chapter. This is a more appropriate pattern to adopt for a handbook. If the reader gets a headache in following through the maze of conflicting data, that is no fault of the author, but indicates rather the need for systematic and crucial research in this field.

The original two excellent chapters on learning have been enriched by two others, one on "The Factor of Maturation", by C. P. Stone, and one on "The Factor of the Conditioned Reflex", by C. L. Hull. The four together make a total of about 220 pages, or the equivalent of an ordinary book on the subject. The added chapters represent current interests and in that sense are less fundamental than the others which deal with nervous mechanisms and experimental studies. It is not improbable that one or both of these newer

chapters might drop out of later editions as interests shift and their material becomes merged into the subject matter of learning. The chapter on maturation is relatively short and might even in this edition have been parcelled out to the other two chapters. However, its author has done unusually well with his assignment, making available the essence of 52 research studies. The chapter on conditioned reflex (73 pages) impresses the reviewer as a model for handbook purposes. The material is thoroughly digested and presented in a systematic fashion. The statements are supported by 119 references; 59 of which have appeared within the last five years. After an historical introduction in which he attributes the first experiment on conditioning to Twitmyer, and defines terms, he gives a detailed description of two typical experiments, one on a secretional reaction, and the other on a motor reaction. This is followed by a brief cataloguing of all the reactions which have been conditioned, and all the stimuli which have been conditioned. He then discusses the various characteristics of the conditioned reflex, such as the dependence on stimulus sequence, rate of acquisition, retention, latencies, summation, inhibition, and disinhibition. Only in the last paragraph or two does he indulge in speculation upon the importance and probable development of the subject in the future. This chapter is surely the most convenient place to get a bird's eye view of the present status of a very perplexing set of problems.

The section dealing with vision, consisting of two chapters in the first edition, receives one additional chapter, a thorough revision of one of the old chapters, and some changes in the other. The new chapter on " Some Neural Correlations ", by C. H. Graham, provides neurological and physiological data that are indispensable for a student of the psychology of vision. There are 127 references cited, 54 of them published since the first edition, in his chapter of 50 pages. One-half of the space is devoted to the problem of retinal interaction and its consequences for interpretation of visual phenomena. This is not only a field where research is most active in the last few years, but is a crucial one for visual theory whether physiological or psychological. The major portion of the remaining space is devoted to " Central Processes " with an enlightening account of the physiological processes underlying contrast, positive and negative afterimages, and binocular fusion. A few pages are devoted to a discussion of the photoreceptor discharge and to electrical responses of the cortex.

The chapter on " The Nature of the Photoreceptor Process ", by

Selig Hecht, has been radically revised. The introduction of side headings make the whole more readable. There are 24 new figures, 5 new tables of data, and 34 references to studies published in 1929 or later. In addition to a reorganization of the material, there are new sections on intermittent stimuli (11 pages) and visual acuity of insects (6 pages), not to mention shorter additions. The most important change, however, is the great expansion of the treatment of color vision. It has been increased from less than 4 pages in the earlier edition to 32 in the revised edition. This will be a welcome change with its 12 new charts and several tables of data. A color theory is offered which is constructed on the basis of Young's three-receptor hypothesis.

Hearing, with two chapters in the original edition, becomes audition in the revision with three chapters. There are no radical changes in the two earlier ones. Hallowel Davis contributes the new one on "The Physiological Phenomena of Audition". Of the 39 references cited, 31 have appeared in 1929 or later. The whole subject is so relatively new that many of the findings await the corroboration or refutation that can come only from repetition at the hands of many investigators. The author distinguishes between cochlear response and auditory nerve response, and lists the differences which researches have demonstrated between them. The Wever-Bray phenomenon would appear to fall in the former class on the evidence to date. As far as auditory theory is concerned, Davis is impelled by the evidence to adopt a place theory of pitch and a multi-fiber theory of intensity as the most probable. He recognizes the tentative nature of these conclusions and the need for continual adjustment of theories to increasing knowledge in such an active field of research.

E. S. Robinson contributes in "Work of the Integrated Organism" the one subject-matter that is entirely new to this volume. He aims to include a treatment of the "productive operations of the intact organism", commonly envisaged within the terms work and fatigue. At the outset he disposes of the artificial distinction between mental work and physical work, both being treated as activities of the intact organism. He rightly points out also the fallacy of limiting the search for the effects of work to energy transformations, neglecting the more strictly psychological changes such as may be revealed through introspection. With these preliminaries disposed of, he launches into the work decrement and its causes. The latter are dealt with under the seven principles previously enunciated by Robinson, and growing out of the now famous 1917 paper of

Dodge on "The Laws of Relative Fatigue". He discusses at some length the tendency of work curves to show an early drop to a stable level of output, one which can be maintained over a fairly long period. This tendency is evident in a wide variety of work curves and is considered more fundamental than the "initial spurt" which is frequently merely an expression of the succeeding drop. A few pages are devoted to "Other Fundamental Factors in Efficiency", including facilitation, distraction and effort, as well as a number of other minor factors illustrated from researches on reaction time.

The plan of presentation adopted by Robinson has enabled him to give in 74 pages a thoroughly adequate and satisfying account of a topic which is as old as the psychological laboratory itself. His treatment is based upon 131 references judiciously chosen from the thousands that were available. The reviewer was impressed by the frequency with which this author was able to suggest problems provocative of further research.

The *Handbook* as a whole does three things: it surveys important fields; it critically evaluates the research in them; and it offers at every turn a multitude of important problems for future research. More than this could scarcely be expected of any single volume. A meticulous reviewer might criticize the relative allotments of space to the various topics, the inclusion of one topic and the omission of another, the injection of personal bias here and there, but over and above all of these he would have to applaud the achievement of assembling such a diverse company of experts in the service of the student of psychology.

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BILLS, ARTHUR G. *General Experimental Psychology.* New York: Longmans, Green and Company, 1934. Pp. xi+620.

For one reason or another books on experimental psychology have been far from satisfactory to both instructor and student. Frequently the subject matter has been too restricted for a particular course or the discussions too technical for the majority of readers. Many will agree that Bills' text is, in many ways, more adequate than previous books in the field. It aims to encompass a wider subject matter than the earlier books although it does limit itself to adult, human, normal psychology. In point of view the book reflects markedly the author's intimate contacts with Carr and Robinson at Chicago.

There are 174 pages devoted to sensation and perception, 170 to learning and memory, 146 to work and fatigue, 44 to association and thought, 52 to emotional and affective processes, and 18 to the appendix, in which are briefly discussed statistics and the psychophysical methods. To devote 50 per cent of the book to learning, memory, work and fatigue appears to be an over-emphasis, especially since inadequate treatment is given such subjects as reaction time, psychophysical methods, perception of time, and smell.

The discussion of sensation and perception is disappointing, principally because the material is frequently condensed almost to an outline which often reduces markedly the meaningfulness of the exposition. For example, the author devotes approximately one-half page (p. 80) to discussing six theories of consonance, an average of less than three lines per theory. One theory is listed by name only.

On learning, memory, work and fatigue the author is at his best. The summaries of the literature are complete and authoritative, the organization of material is eminently satisfactory, and the documentation is adequate. It is perhaps the finest survey of the field that we have.

Bills, in general, is not ready to accept the Gestalt "insight" interpretation of learning. "The Gestalt theory seems to imply that there is a tension established within the organism with reference to the problem, which is conceived as a total situation or Gestalt to be responded to." "Aside from presenting some interesting but questionable physical analogies for their hypothetical tensions or stresses, the Gestalt school seems to attempt to answer the problem chiefly by denying it." Contrasted to this, the importance of trial and error in learning is emphasized, especially in the maze situation. "A maze cannot be learned unless the subject has some experience with the incorrect movements." In the case of higher organisms, however, the process of learning is probably accompanied by a growing insight into the solution which is reflected by an increased relevance of attack on the problem.

In some instances the author's uncritical acceptance of results and his interpretations may be questioned. For instance, it is stated that Fox's subjects learned most rapidly and retained best the sonnets which they preferred (p. 230). Analysis of Fox's procedure reveals that the preference was expressed at the end of the experiment. It is quite possible that they preferred the sonnets which were easiest to

learn. Unpublished data of the reviewer indicate that this latter interpretation is correct.

In citing Stratton's experiment on inverted vision the author seems to imply that the re-orientation at the end of 8 days was constant; that there were no lapses from the "right-side-up" appearance of the visual field. According to Stratton the experience of "right-side-up" lasted only when the "new localization" of his body was vivid. There were involuntary lapses and willful recalls which ruptured the newly established harmony and led to viewing the scene as from an inverted body. Furthermore, the statement that Ewert's failure to corroborate Stratton's finding was in part due to the limiting of the former's experiment to the laboratory situation is a misinterpretation. If we deduct the time spent in the laboratory by Ewert's subjects from the total time of inverted vision we find that four to five times as much time was devoted to activities outside the laboratory as in it. These informal activities correspond very well with those of Stratton. It must be admitted also that Ewert's experiment was much more adequately controlled than that of Stratton.

Some of the author's presentation should be modified to prevent misinterpretation or to bring it into harmony with recent experimental findings. Examples are listed: (1) "Range of attention" or "span of attention" (p. 410) is a misnomer as Dallenbach has shown. It should be "range of apprehension". (2) The statement that auditory sensitivity to vibrations ranges from 15 to 40,000 vibrations per second (p. 22) places the upper limit too high. Recent work indicates that the upper limit probably never goes above 24,000 vibrations. In practice it is usually found to be considerably below 20,000. (3) Recent findings indicate that red-green color blindness occurs in about 8 per cent of males and 1 per cent of females rather than 4 per cent and 0.5 per cent respectively (p. 55). (4) The tails of the normal curve of distribution should not touch the base-line as they do in Figure 113. (5) Few will agree that statistical techniques are methods of control in experimental observation (p. 10).

There are, in general, two ways that this book could be made even more adequate than at present: (1) by an expansion of the exposition at various places to a degree of unequivocal clearness; (2) by a more thorough interpretation by the author of his excellent summaries. There occurs too frequently the tendency to summarize without evaluation.

It is true that one is disappointed with the first part of this book,

and that many specific details appear inadequate. Nevertheless, the sections on learning and memory, work and fatigue, and association and thought constitute an excellent contribution to psychological literature.

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FLUGEL, J. C. *A Hundred Years of Psychology: 1833–1933.* New York: The Macmillan Company, 1933. Pp. 384.

In Britain, where it is possible to ask students to approach a science historically almost from the beginning of their study, there is an obvious place for the present volume, "deliberately constructed on more impressionistic and less systematic lines" than the standard histories of Brett, Boring, and Murphy. It will find a welcome in this country, however, both as a supplement and as a substitute for these latter. While the book is not for the lazy-minded to whom a technical term is an insuperable obstacle, difficult and intricate issues are clarified without undue simplification in wholly admirable fashion.

The plan of the book is straightforward. First we are shown the status of psychology in 1833 (70 pp.). The date is not ill chosen, for Herbart had only recently published his great work, *Psychologie als Wissenschaft.* Yet Part II (which carries the story forward to 1860) shows no new development but only an expansion and refinement of the tendencies already dimly visible in 1833 (40 pp.). Part III (1860–1900) is thus the "historical" period from the standpoint of modern psychology (114 pp.).

As might be expected of a British writer (albeit one German-born), there is a detailed and sympathetic treatment of Bain, Galton and particularly of Spencer. Yet the genius of Helmholtz is strikingly set forth in a brief chapter which justifies his position as the foremost figure of the "new" psychology. The relation of Brentano to Ward and Stout (and McDougall as a pupil of Stout) and to the American functionalists is clarified. Probably the most unsatisfactory treatment is in the brief chapter devoted to "France and the Development of Abnormal Psychology". Flugel concedes that Ribot is important but does not make clear why. Scant justice is done to the richness and suggestiveness of Janet's work—perhaps because of the author's bias in favor of the rival psychoanalytic position. In general, for this period both Boring and Murphy are much to be preferred.

The modern period (1900–1933) of course presents difficult prob-

lems of both organization and emphasis. The strength of the Würzburg School is more justly appraised than by most critics; Flugel believes the study of the dynamics of thinking by experimental introspection is not dead but sleeping. The variety of McDougall's contributions to psychology (rather unknown to the younger generation of Americans) is brought out by numerous references *passim;* a brief chapter deals specifically with his hormic hypothesis. The originality and the theoretic importance of Spearman's factor theory is likewise clearly and justly appraised without, unfortunately, much criticism of some of the experimental work. The treatment of other contemporary currents is clear and sympathetic.

It is in his treatment of psychoanalysis, however, that Flugel is most illuminating. For most of us, Freud is clearly an important but rather esoteric figure. His influence upon our whole Western culture is admittedly great but he has only slightly and indirectly modified our psychology. The reviewer has read better expositions of Freud but none richer in suggestions of the way psychoanalysis can be expected eventually to be assimilated into the turbulent stream of general psychology.

It may be of interest to note national tendencies in the author's treatment. A chronological table of major events is given. Of those before 1901, 103 are German, 36 are British, 24 are American, 12 are French, and 3 are "other". Since 1901, of course, the emphasis has shifted to America; the corresponding figures are 18, 19, 16, 3, and 4. Interestingly enough, a sampling of persons listed in the index shows Americans strikingly in the lead with the other three major countries about equal. The British seem to lead in the number of articles and books referred to, with America second. It looks as if American preeminence were primarily a matter of numbers and of quantity. What will be the picture from the perspective of a second hundred years?

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Hulin, Wilbur S. *A Short History of Psychology.* New York: Henry Holt and Company, 1934. Pp. vi+189.

This excellent little treatise is just what the title implies, a "short" history; it is "a brief, elementary account of the development of psychology". Intended "for the beginning student who often finds that modern psychology differs considerably from his expectations", the author endeavors "to show the gradual change from confusion and self-reference to the cautious, impersonal methods of scientific

reflection through which have come the emergence and then the development of the concept of mind". Although the beginning student may at first wonder what the early chapters have to do with psychology and "mind", the relationship should become clear as the theme is developed from the time of the early Greeks to date. The consideration of certain facts from general history (*e.g.*, the Renaissance) helps the logical import; and even the seasoned student of psychological history will probably find a few new facts as to the influence of philosophy and physiology.

The book should show more relationships, however, between the views of different writers, particularly as to their anticipation of the psychology of today. In addition, the footnotes would be more helpful to the beginning student if references were given to translations, or to secondary sources, rather than to original publications in other languages. Various branches of psychology, animal, abnormal, individual, etc., are discussed, but little or no attention is given to the field of social psychology.

This history should prove a welcome supplementary text-book to many elementary courses. It is not just a "re-hash" of the histories of Boring and Murphy, and it is surprising how much relevant material is packed into so few pages. The conciseness of the discussion may be indicated by the fact that the views of Locke, Berkeley, Hume, and Hartley are given in a total of four pages. The book includes a general bibliography, and a complete name-index and subject-index.

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FINANCIAL REPORTS OF PUBLICATION ENTERPRISES OF THE AMERICAN PSYCHOLOGICAL ASSOCIATION

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Psychological Abstracts

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To Editorial Office	206.79	
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Balance, December 31, 1934		7,257.89
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Psychological Abstracts

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From Princeton Business Office, *Psychological Abstracts*	206.79	
		6,783.85
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Disbursements

Associate Editor's salary	$3,000.00	
Secretary's salary	1,500.00	
Editorial Office expenses	678.12	
Abstractors	1,425.52	
Translators	188.45	
Tax on checks	7.82	
		$6,799.91
Balance, December 31, 1934		116.66
		$6,916.57

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